FOR THE

GUIDE

TO THE

DEPARTMENT OF PUBLIC WORKS,

OR

QUESTIONS

IN

FRACTIONS, DECIMALS,
MENSURATION OF SUPERFICIES AND SOLIDS, &c. &c.
(FROM HUTTON AND OTHERS,)
WORKED OUT AND EXPLAINED BY EXAMPLES,
AND INTENDED
FOR SELF-INSTRUCTION OF PARTIES DESIROUS OF ENTERING
THE
Department of Public Works, and the Commissariat Department.
WITH
DETAILED STATEMENTS OF THE NUMBER OF WORK PEOPLE AND QUANTITIES OF
MATERIAL REQUIRED FOR THE VARIOUS KINDS OF WORK EXECUTED IN THE
D. P. W. AS ALSO A REFERENTIAL INDEX OF THE PRINCIPAL ORDERS
ISSUED TO THE OFFICERS IN THE D. P. W. THROUGH THE
CHIEF ENGINEER SINCE THE FORMATION OF THE
REVISED SYSTEM ACCORDING TO G. O. G. G.
OF 21ST APRIL, 1854, AND OTHER
RULES AND REGULATIONS
FOR THE D. P. W.

BY

D. A. GANTZER.

Revised Edition.

CALCUTTA:
THACKER, SPINK AND CO.
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1858.

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IMPROVED EDITION.

DEDICATED, BY PERMISSION,

TO

THE RIGHT HONORABLE

LORD VISCOUNT CANNING,

Governor General of India,

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PREFACE.

THIS Second or Revised Edition of the Guide will, it is hoped, prove still more useful than the first. It contains an abstract of the Standing Orders of Government issued to the Department of Public Works, from the commencement of the working of the new system to the latest date; details of labor and materials required for the construction of each description of Work, and Rules and Regulations for the guidance of Officers in the D. P. W. and of those anxious to enter it, with other necessary information of general utility. Parties in this country and those daily arriving from England, particularly Officers of H. M.'s and the Honorable Company's services, who may have to erect buildings for their residence in lieu of those destroyed by the Rebels in the N. W. P., will find the list of labour and Materials shewing the proportion required for each description of work, useful as a check.

This unpretending little Compendium will also, it is hoped, be of use to candidates for the Commissariat Department, agreeably to G. O. G. G. of 16th September, 1851, and to the subordinate builders and contractors in the Railway Department.

EXPLANATION OF CERTAIN CHARACTERS THAT WILL BE FOUND IN THE WORK.

+	signifies	*plus*, or *addition.*
−	,,	*minus*, or *subtraction.*
×	,,	*multiplication.*
÷	,,	*division.*
: :: :	,,	*proportion.*
=	,,	*equality.*
$\sqrt{}$	,,	*square-root.*
$\sqrt[3]{}$	,,	*cube-root.*
$\backsim$	,,	*difference between two numbers,*

(when it is not known which is the greater.)

MONEY, WEIGHTS, AND MEASURES.

Money.

4 Farthings = 1 Penny,—*d.*
12 Pence = 1 Shilling,—*s.*
5 Shillings = 1 Crown,—*c.*
20 Shillings = 1 Pound,—£.
21 Shillings = 1 Guinea,—*g.*

12 Pie = 1 Anna,—*a.*
16 Annas, = 1 Rupee,—*R.*
16 Rupees, = 1 Gold Mohur,—*g.m.*

Troy Weight.

24 Grains, *grs.*=1 Pennyweight.—*dwt.*
20 Pennyweights = 1 Ounce,—*oz.*
12 Ounces = 1 Pound,—*lb.*

Indian Weight.

16 Chittacks,—*cks.* = 1 Seer,—*sr.*
40 Seers = 1 Maund,—*md.*
A Seer is equal to 2*lbs.* Avoirdupois.

Apothecaries' Weight.

20 Grains,—*grs.* = 1 Scruple,—*sc.*
3 Scruples = 1 Dram,—*dr.*
8 Drams = 1 Ounce,—*oz.*
12 Ounces = 1 Pound,—*lb.*

Avoirdupois Weight.

16 Drams,—*drs.* = 1 Ounce,—*oz.*
16 Ounces = 1 Pound,—*lb.*
28 Pounds = 1 Quarter,—*qr.*
4 Quarters=1 Hundred Weight,—*cwt.*
20 Hundred Weight = 1 Ton,—*ton.*

Long Measure.

3 Barleycorns,—*b.-c.* = 1 Inch,—*in.*
12 Inches = 1 Foot,—*ft.*
3 Feet = 1 Yard,—*yd.*
6 Feet = 1 Fathom,—*fth.*
5½ Yards = 1 Pole or Rod,—*pl.* or *rd.*
40 Poles = 1 Furlong,—*fur.*
8 Furlongs = 1 Mile,—*m.*
3 Miles = 1 League, *lea.*
69½ Miles nearly, = 1 Degree,—*deg.*

Note.—In Bengal measure a Biggah is a Square of 120 feet, containing 14,400 square feet.

Cloth Measure.

2¼ Inches = 1 Nail,—*nl.*
4 Nails = 1 Quarter of a Yard,—*qr.*
3 Quarters = 1 Ell Flemish,—*e. F.*
4 Quarters = 1 Yard,—*yd.*
5 Quarters = 1 Ell English,—*e. E.*

Dry or Corn Measure.

2 Pints,—*pts.* = 1 Quart,—*qt.*
2 Quarts = 1 Pottle,—*pot.*
2 Pottles = 1 Gallon,—*gal.*
2 Gallons = 1 Peck,—*pec.*
4 Pecks = 1 Bushel,—*bu.*
8 Bushels = 1 Quarter,—*qr.*
5 *Qrs.* = 1 Wey, Load, or Ton Wey.
2 Weys = 1 Last,—*l.*

Ale and Beer Measure.

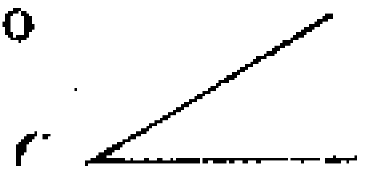
2 Pints,—*pts.* = 1 Quart,—*qt.*
4 Quarts = 1 Gallon,—*gal.*
36 Gallons = 1 Barrel,—*bar.*
1½ Barrel = 1 Hogshead,—*hhd.*
2 Barrels = 1 Puncheon,—*pun.*
2 Hhds. = 1 Butt,—*butt.*
2 Butts, = 1 Tun,—*tun.*

Wine Measure.

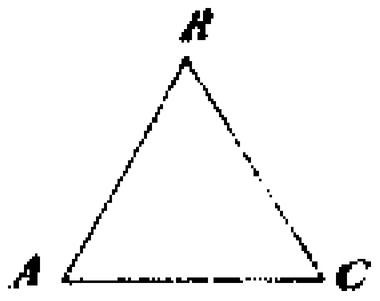
2 Pints = 1 Quart,—*qt.*
4 Quarts = 1 Gallon,—*gal.*
42 Gallons = 1 Tierce,—*tier.*
63 Gallons = 1 Hogshead,—*hhd.*
2 Hogsheads = 1 Pipe or Butt.,—*butt, pi.*
2 Pipes, or 4 Hhds. = 1 Tun,—*tun.*

DEFINITIONS.

(1*st.*) An *angle* is formed by the meeting of two straight lines at the point *C.*



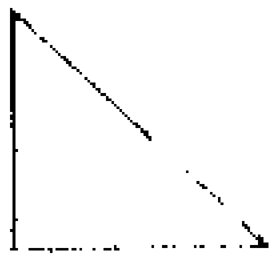
(2*nd.*) A *triangle* is a figure of three sides and three angles.



(3*rd.*) An *obtuse-angle* triangle has one obtuse angle. An *acute-angle* triangle has all its angles acute, but whether a triangle is right-angled, obtuse-angled, or acute-angled still the three angles of every triangle will only amount to 180°.

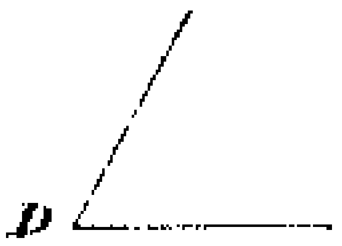
(4*th.*) An *equilateral* triangle has three sides equal, and an *isosceles* triangle has only two sides equal.

(5*th.*) A *right-angle* triangle is that which has only one right angle.

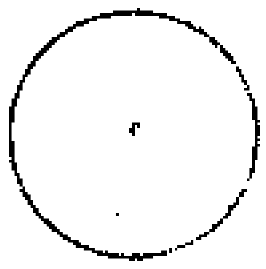


(6*th.*) An angle less than 90° is called an *acute* angle, more than 90° an *obtuse* angle, and exactly 90° a *right* angle.

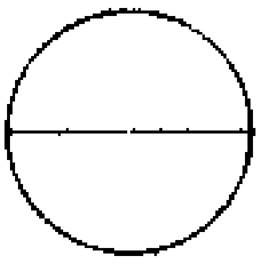
(7*th.*) All the angles that can be made round onepoint amount to 360 degrees, *i. e.*, all the angles that could be made by straight lines terminating at the point *D,* amount to 360 degrees.



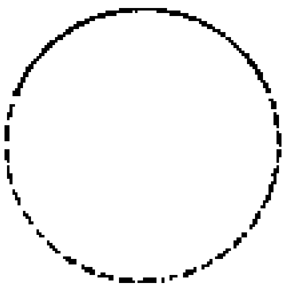
(8*th.*) A *circle* is a figure bounded by a curve called the *circumference,* which is equally distant from a point within called the *centre.* The circumference is supposed to be divided into 360 equal parts, called degrees.



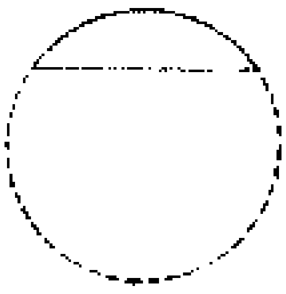
(9*th.*) The *diameter* of a circle is a straight line passing through the centre and terminating at the circumference.



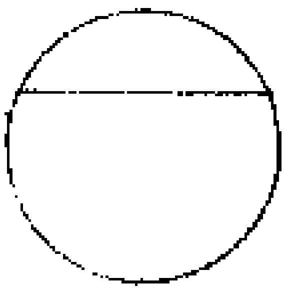
(10*th.*) An *arc* of a circle is any part of the circumference.



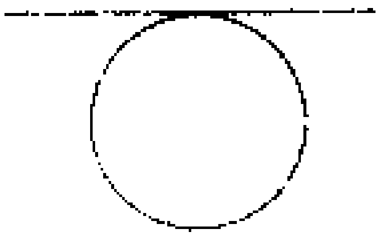
(11*th.*) A *chord* is a right line joining the two extremities of an arc.



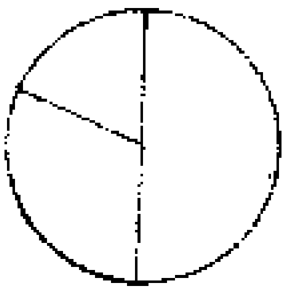
(12*th.*) A *segment* is any part of a circle bounded by an arc and its chord.



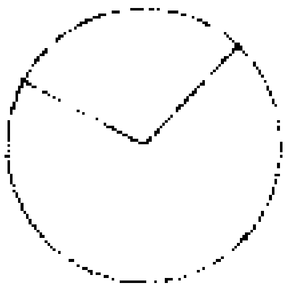
(13*th.*) A *tangent* is a line that touches a figure without cutting it.



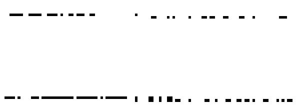
(14*th.*) The *radius* of a circle is a straight line drawn from the centre to the circumference.



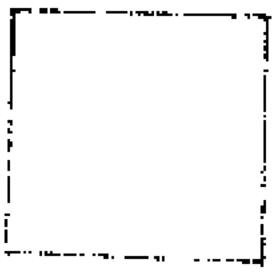
(15*th.*) A *sector* is any part of a circle bounded by an arc and two radii drawn to its extremities.



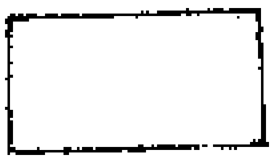
(16*th.*) Lines are said to be *parallel* when they have no inclination to one another, and will never meet though produced to any distance, thus:



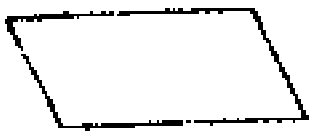
(17*th.*) A *square* has four equal sides and four right angles, *i. e.*, four angles of 90° each.



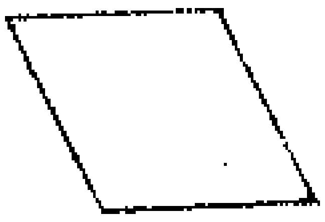
(18*th.*) A *rectangle* is a parallelogram having four right angles, but the opposite sides only are equal.



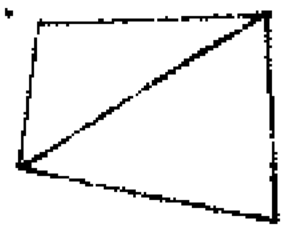
(19*th.*) A *rhomboid* is an obliqued-angle parallelogram.



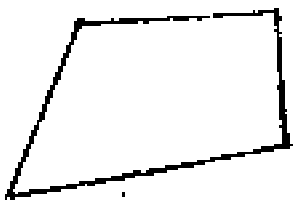
(20*th.*) A *rhombus* is an equilateral rhomboid, having all its sides equal, but its angles oblique.



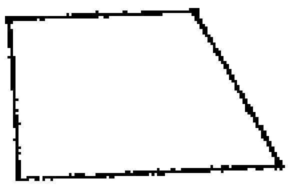
(21*st.*) A *diagonal* is a right line crossing a figure, and terminating at its two opposite angles.



(22*nd.*) A *trapezium* is a four-sided figure having none of its opposite sides parallel.



(23*rd.*) A *trapezoid* has only a pair of its opposite sides parallel.



(24*th.*) A five-sided figure is called a *pentagon.*
A six-sided figure is called a *hexagon.*
A seven-sided figure is called a *heptagon.*
An eight-sided figure is called an *octagon.*
A nine-sided figure is called a *nonagon.*
A ten-sided figure is called a *decagon.*

NOTE.—All these figures are also called by the general name of *polygons.*

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VULGAR FRACTIONS.

A FRACTION, or broken number, is an expression of a part or parts of something considered as a whole: it is denoted by two numbers placed one below the other, with a line between them, thus:—

$$\left.\begin{array}{l}3\ldots\textit{Numerator},\\ \overline{4}\ldots\textit{Denominator},\end{array}\right\}\text{whic his named “3-}\textit{fourths}\text{.”}$$

The Denominator, or number placed below the line, shows how many equal parts the whole quantity is divided into, and represents the Divisor in Division,—and the Numerator, or number set above the line, shows how many of these parts are expressed by the Fraction; being the Remainder after Division: also both these numbers are in general named the *terms* of the Fraction.

Fractions are either *Proper*, *Improper*, *Simple*, *Compound*, *Mixed*, or *Complex*.

A *Proper Fraction* is when the Numerator is less than the Denominator; as $\frac{1}{2}$, or $\frac{2}{3}$, or $\frac{3}{5}$, &c.

An *Improper Fraction* is when the Numerator is equal to, or exceeds, the Denominator; as $\frac{3}{3}$, or $\frac{5}{4}$, or $\frac{7}{5}$, &c.

A *Simple Fraction* is a single expression denoting any number of parts of the integer; as $\frac{2}{3}$, or $\frac{3}{2}$.

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A *Simple Fraction* is a single expression denoting any number of parts of the integer; as $\frac{2}{3}$, or $\frac{3}{2}$.

A *Compound Fraction* is the fraction of a fraction, or several fractions connected with the word *of* between them; as $\frac{1}{2}$ of $\frac{2}{3}$, or $\frac{3}{5}$ *of* $\frac{5}{6}$ *of* 3, &c.

A *Mixed Number* is composed of a Whole Number and a fraction together; as $3\frac{1}{4}$, or $12\frac{4}{5}$, &c.

A *Complex Fraction* is one that has a fraction, or a Mixed Number, for its Numerator or its Denominator, or both; as $\frac{\frac{1}{2}}{3}$, or $\frac{2}{\frac{3}{4}}$, or $\frac{\frac{2}{3}}{\frac{4}{5}}$, or $\frac{3\frac{1}{5}}{4}$, &c. It is, however, very seldom brought into requisition.

A Whole or integer Number may be expressed like a fraction, by writing 1 below it as a Denominator; so 3 is $\frac{3}{1}$, or 4 is $\frac{4}{1}$, &c.

A fraction denotes division, and its value is equal to the quotient obtained by dividing the Numerator by the Denominator; so $\frac{12}{4}$ is equal to 3, and $\frac{21}{5}$ is equal to $4\frac{1}{5}$.

Hence, then, if the Numerator be less than the Denominator, the value of the fraction is less than 1; but if the Numerator be the same as the Denominator, the fraction is just equal to 1; and if the Numerator be greater than the Denominator, the fraction is greater than 1.

REDUCTION OF VULGAR FRACTIONS.

Reduction of Vulgar Fractions is the bringing them out of one form of denomination into another, commonly to prepare them for the operations of Addition, Subtraction, &c., of which there are several cases.

PROBLEM.

To find the Greatest Common Measure of two or more numbers.

The Common Measure of two or more numbers is that number which will divide them all without Remainders; so 3 is a Common

Measure of 18 and 24,—the quotient of the former being 6 and of the latter 8; and the greatest number that will do this is the Greatest Common Measure: so 6 is the Greatest Common Measure of 18 and 24, the quotient of the former being 3 and of the latter 4, which will not both divide further.

RULE.

If there be two numbers only, divide the greater by the less; then divide the Divisor by the Remainder, and so on, dividing always the last Divisor by the last Remainder, till nothing remains; so shall the last Divisor of all be the Greatest Common Measure sought.

When there are more than two numbers, find the Greatest Common Measure of two of them, as before; then do the same for that Common Measure and another of the numbers, and so on through all the numbers; so will the Greatest Common Measure last found be the answer.

If it happen that the Common Measure thus found is 1, then the numbers are said to be incommensurable, or not having any Common Measure.

EXAMPLES.

(1*st.*) What is the greatest common measure of 246 and 372?

```
246 |372| 1
    |246|
    -------
    126 |246| 1
        |126|
        -------
        120 |126| 1
            |120|
        -------
          6 |120| 20
            |120|
            -----
```

6, *Answer.*

(*2nd.*) What is the greatest common measure of 324, 612, and 1032?

$$\begin{array}{r|r|l} 324 & 612 & 1 \\ & 324 & \\ \hline 288 & 324 & 1 \\ & 288 & \\ \hline 36 & 288 & 8 \\ & 288 & \\ \hline & \ldots & \end{array} \qquad \begin{array}{r|r|l} 36 & 1032 & 28 \\ & 72 & \\ \hline & 312 & \\ & 288 & \\ \hline 24 & 36 & 1 \\ & 24 & \\ \hline 12 & 24 & 2 \\ & 24 & \\ \hline & .. & \end{array}$$

12, *Answer.*

CASE I.

To abbreviate or reduce Fractions to their Lowest Terms.

Divide the Terms of the given fraction by any number that will divide them without a Remainder; then divide these quotients again in the same manner, and so on, till it appears that there is no number greater than 1 which will divide them; then the fraction will be in its Lowest Terms.

Or, divide both the Terms of the fraction by their Greatest Common Measure at once, and the quotients will be the Terms of the Fraction required of the same value as at first.

EXAMPLES.

(*1st.*) Reduce $\frac{195}{780}$ to its lowest terms.

$$\begin{array}{r|r|l} 195 & 780 & 4 \\ & 780 & \\ \hline & \ldots & \end{array}$$

$$\text{hence, } 195 \left| \frac{195}{780} \right. = \tfrac{1}{4};$$

$$\text{or, } \frac{195}{780} = \frac{39}{156} = \frac{13}{52} = \tfrac{1}{4}, \textit{ Answer.}$$

(2*nd*.) Reduce $\frac{136}{204}$ to its lowest terms.

$$\begin{array}{rr|r|l} 136 & 204 & 1 & \\ & 136 & & \\ \hline & 68 & 136 & 2 \\ & & 136 & \\ \hline \end{array}$$

...

hence, $68 \left| \frac{136}{204} \right. = \frac{2}{3}$;

or, $\frac{136}{204} = \frac{34}{51} = \frac{2}{3}$, *Answer.*

(3*rd*.) Reduce $\frac{525}{630}$ to its lowest terms.

$$\begin{array}{rr|r|l} 525 & 630 & 1 & \\ & 525 & & \\ \hline & 105 & 525 & 5 \\ & & 525 & \\ \hline \end{array}$$

...

hence, $105 \left| \frac{525}{630} \right. = \frac{5}{6}$;

or, $\frac{525}{630} = \frac{35}{52} = \frac{5}{6}$, *Answer.*

(4*th*.) Reduce $\frac{30}{125}$ to its lowest terms.

$$\begin{array}{rr|r|l} 30 & 125 & 4 & \\ & 120 & & \\ \hline & 5 & 30 & 6 \\ & & 30 & \\ \hline \end{array}$$

...

hence, $5 \left| \frac{30}{125} \right. = \frac{6}{25}$, *Answer.*

(5*th.*) Reduce $\frac{208}{684}$ to its lowest terms.

$$\begin{array}{r|r|l} 208 & 684 & 3 \\ & 624 & \\ \hline 60 & 208 & 3 \\ & 180 & \\ \hline 28 & 60 & 2 \\ & 56 & \\ \hline 4 & 28 & 7 \\ & 28 & \\ \hline \end{array}$$

. .

hence, $4 \left| \frac{208}{684} \right. = \frac{52}{171}$, *Answer.*

(6*th.*) Reduce $\frac{192}{576}$ to its lowest terms.

$$\begin{array}{r|r|l} 192 & 576 & 3 \\ & 576 & \\ \hline \end{array}$$

. . .

Hence $192 \left| \frac{192}{576} \right. = \frac{1}{3}$;

or, $\frac{192}{576} = \frac{32}{96} = \frac{2}{6} = \frac{1}{3}$, *Answer.*

(7*th.*) Reduce $\frac{825}{960}$ to its lowest terms.

$$\begin{array}{r|r|l} 825 & 960 & 1 \\ & 825 & \\ \hline 135 & 825 & 6 \\ & 810 & \\ \hline 15 & 135 & 9 \\ & 135 & \\ \hline \end{array}$$

. . .

hence, $15 \left| \frac{825}{960} \right. = \frac{55}{64}$, *Answer.*

or, $\frac{825}{960} = \frac{165}{198} = \frac{55}{64}$, *Answer.*

(8*th.*) Reduce $\frac{5184}{6912}$ to its lowest terms.

$$\begin{array}{rrrr}
5184 & 6912 & 1 & \\
 & 5184 & & \\
\cline{2-3}
 & 1728 & 5184 & 3 \\
 & & 5184 & \\
\cline{3-3}
 & & \cdots\cdots &
\end{array}$$

hence, $1728 \left| \frac{5184}{6912} \right. = \frac{3}{4}$;

or, $\frac{5184}{6912} = \frac{864}{1152} = \frac{44}{192} = \frac{9}{12} = \frac{3}{4}$, *Answer.*

* * *

CASE II.

To reduce a Mixed Number to its equivalent Improper Fraction.

Multiply the integer, or Whole Number, by the Denominator of the fraction, and to the product add the Numerator; then set that sum above the Denominator for the fraction required.

Examples.

(1*st.*) Reduce $12\frac{7}{9}$ to a fraction.

$$\begin{array}{r}
12\frac{7}{9} \\
9 \\
\hline
108 \\
7 \\
\hline
115 \\
\hline
9
\end{array}
\qquad \text{or, } \frac{(12 \times 9) + 7}{9} = \frac{115}{9}, \textit{ Answer,}$$

(*2nd.*) Reduce $6\frac{7}{10}$ to a fraction.

$7\frac{4}{10}$
10
—
70
4
—
74
—
10

or, $$\frac{(7 \times 10) + 4}{10} = \frac{74}{10}\text{, } \textit{Answer.}$$

3rd.) Reduce $183\frac{5}{21}$ to a fraction.

$183\frac{5}{21}$
21
—
183
366
5
—
3848
—
21

or, $$\frac{(21 \times 183) + 5}{} = \frac{3848}{21}\text{, } \textit{Answer.}$$

(*4th.*) Reduce $56\frac{13}{22}$ to a fraction.

$56\frac{13}{22}$
22
—
112
112
13
—
1245
—
22

or, $$\frac{(56 \times 22) + 13}{} = \frac{1245}{22}\text{, } \textit{Answer.}$$

(*5th.*) Reduce $183\frac{5}{21}$ to a fraction.

$183\frac{5}{21}$
21
—
183
366
5
—
3848
—
21

or, $$\frac{(21 + 183) + 5}{} = \frac{3848}{21}\text{, } \textit{Answer.}$$

(6*th.*) Reduce $13\frac{4}{5}$ to a fraction.

$$\begin{array}{r} 13\frac{4}{5} \\ 5 \\ \hline 65 \\ 4 \\ \hline 69 \\ \hline 5 \end{array} \qquad \text{or, } \frac{(5 \times 13) + 4}{} = \frac{69}{5}, \textit{ Answer.}$$

(7*th.*) Reduce $27\frac{2}{9}$ to a fraction.

$$\begin{array}{r} 27\frac{2}{9} \\ 9 \\ \hline 243 \\ 2 \\ \hline 245 \\ \hline 9 \end{array} \qquad \text{or, } \frac{(27 \times 9) + 2}{} = \frac{245}{9}, \textit{ Answer.}$$

(8*th.*) Reduce $514\frac{5}{16}$ to a fraction.

$$\begin{array}{r} 514\frac{5}{16} \\ 16 \\ \hline 8224 \\ 5 \\ \hline 8229 \\ \hline 16 \end{array} \qquad \text{or, } \frac{(514 \times 16) + 5}{} = \frac{8229}{16}, \textit{ Answer.}$$

CASE III.

To reduce an Improper Fraction to its equivalent or Mixed Number.

Divide the Numerator by the Denominator, and the quotient will be the Whole or Mixed Number sought.

EXAMPLES.

(1*st.*) Reduce $\frac{56}{7}$ to its equivalent number.

$$\begin{array}{l|l} 7 & \underline{56} \\ & \;\;8 \end{array} \qquad \text{or, } 56 \div 7 = 8, \textit{ Answer.}$$

(*2nd.*) Reduce $\frac{1362}{25}$ to its equivalent number.

$$\begin{array}{r|l} 25 & 1362 \\ \hline & 52\frac{2}{25} \end{array}$$

or, $1362 \div 25 = 52\frac{2}{25}$, *Answer.*

(*3rd.*) Reduce $\frac{2918}{17}$ to its equivalent number.

$$\begin{array}{r|l} 17 & 2918 \\ \hline & 171\frac{11}{17} \end{array}$$

or, $2918 \div 17 = 171\frac{11}{17}$, *Answer.*

(*4th.*) Reduce $\frac{3848}{21}$ to its equivalent number.

$$\begin{array}{r|l} 21 & 3848 \\ \hline & 183\frac{5}{21} \end{array}$$

or, $3848 \div 21 = 183\frac{5}{21}$, *Answer.*

(*5th.*) Reduce $\frac{1245}{22}$ to its equivalent number.

$$\begin{array}{r|l} 22 & 1245 \\ \hline & 56\frac{13}{22} \end{array}$$

or, $1245 \div 22 = 56\frac{13}{22}$, *Answer.*

(*6th.*) Reduce $\frac{69}{5}$ to its equivalent number.

$$\begin{array}{r|l} 5 & 69 \\ \hline & 13\frac{4}{5} \end{array}$$

or, $69 \div 5 = 13\frac{4}{5}$, *Answer.*

(*7th.*) Reduce $\frac{245}{9}$ to its equivalent number.

$$\begin{array}{r|l} 9 & 245 \\ \hline & 27\frac{2}{9} \end{array}$$

or, $245 \div 9 = 27\frac{2}{9}$, *Answer.*

(*8th.*) Reduce $\frac{8229}{16}$ to its equivalent number.

$$\begin{array}{r|l} 16 & 8229 \\ \hline & 514\frac{5}{16} \end{array}$$

or, $8229 \div 16 = 514\frac{5}{16}$, *Answer.*

CASE IV.

To reduce a Whole Number to an equivalent Fraction having a given Denominator.

Multiply the Whole Number by the given Denominator; then set the product over the said Denominator, and it will form the fraction required.

EXAMPLES.

(1*st.*) Reduce 12 to a fraction whose Denominator shall be 13.

Here $12 \times 13 = 156$; then $\frac{156}{13}$ is the *answer*;

[for $\frac{156}{13} = 156 \div 13 = 12$ the *proof.*]

(2*nd.*) Reduce 27 to a fraction whose Denominator shall be 11.

Here $27 \times 11 = 297$; then $\frac{297}{11}$ is the *answer*;

[for $\frac{297}{11} = 297 \div 11 = 27$ the *proof.*]

* * *

CASE V.

To reduce a Compound Fraction to an equivalent Simple one.

Multiply all the Numerators together for a Numerator, and all the Denominators together for a Denominator, and they will form the Simple Fraction sought.

When Part of the Compound Fraction is a Whole or Mixed Number, it must first be reduced to a fraction by one of the former cases.

And when it can be done, any two terms of the fraction may be divided by the same number, and the quotients used instead of them: or when there are terms that are common, they may be omitted or cancelled.

EXAMPLES.

(1*st.*) Reduce $\frac{2}{3}$ *of* $\frac{3}{5}$ *of* $\frac{5}{9}$ to a simple fraction.

$$\frac{2\times3\times5}{3\times5\times9}=\frac{30}{135}=\frac{6}{27}=\tfrac{2}{9},\ \textit{Answer.}$$

$$\text{or, }\frac{2\times\cancel{3}\times\cancel{5}}{\cancel{3}\times\cancel{5}\times9}=\frac{2}{9};$$

—that is, 3 and 5 being common to both Numerator and Denominator, they are cancelled in both terms of the fraction, leaving 2 in the former and 9 in the latter,—consequently $\frac{2}{9}$ is the Simple Fraction required.

(2*nd.*) Reduce $\frac{3}{7}$ *of* $\frac{4}{5}$ to a simple fraction.

$$\frac{3\times4}{7\times5}=\tfrac{12}{35},\ \textit{Answer.}$$

(3*rd.*) Reduce $\frac{2}{5}$ *of* $\frac{5}{8}$ *of* $3\frac{1}{2}$ to a simple fraction.

First, by Case II., $3\frac{1}{2}=\underline{(3\times2)+1}=\frac{7}{2}$;

$$\text{then, }\frac{2\times5\times7}{5\times8\times2}=\frac{70}{80}=\frac{7}{8};$$

$$\text{or, }\frac{\cancel{2}\times\cancel{5}\times7}{\cancel{5}\times8\times\cancel{2}}=\tfrac{7}{8},\ \textit{Answer.}$$

(4*th.*) Reduce $\frac{2}{7}$ *of* $\frac{5}{8}$ *of* $\frac{7}{2}$ *of* 4 to a simple fraction.

$$\frac{2\times5\times7\times4}{7\times8\times2\times1}=\frac{280}{112}=\frac{70}{28}=\tfrac{5}{2};$$

$$\text{or, }\frac{\cancel{2}\times5\times\cancel{7}\times\cancel{4}}{\cancel{7}\times\underset{2}{\cancel{8}}\times\cancel{2}\times1}=\tfrac{5}{2},\ \textit{Answer.}$$

(5*th.*) Reduce 2 and $\frac{2}{5}$ *of* $\frac{5}{6}$ to a fraction.

$$2+\frac{2\times5}{5\times6}=2+\frac{10}{30}=2\tfrac{1}{3}=\tfrac{7}{3};$$

$$\text{or, }2+\frac{\overset{1}{\cancel{2}}\times\cancel{5}}{\cancel{5}\times\underset{3}{\cancel{6}}}=2\tfrac{1}{3}=\tfrac{7}{3},\ \textit{Answer.}$$

(*6th.*) Reduce $\frac{5}{9}$ *of* $\frac{4}{7}$ *of* $\frac{11}{12}$ to a simple fraction.

$$\frac{5\times4\times11}{9\times7\times12}=\frac{220}{756}=\frac{55}{189};$$

or, $\dfrac{5\times\cancel{4}\times11}{9\times7\times\underset{3}{\cancel{12}}}=\frac{55}{189}$, *Answer.*

(*7th.*) Reduce $\frac{11}{12}$ *of* $\frac{13}{14}$ *of* $\frac{21}{29}$ to a simple fraction.

$$\frac{11\times13\times21}{12\times14\times29}=\frac{3003}{4872}=\frac{143}{232};$$

or, $\dfrac{11\times13\times\overset{3}{\cancel{21}}}{\underset{4}{\cancel{12}}\times\underset{2}{\cancel{14}}\times29}=\frac{143}{232}$, *Answer.*

(*8th.*) Reduce $\frac{3}{4}$ *of* $\frac{5}{6}$ *of* $\frac{9}{10}$ to a simple fraction.

$$\frac{3\times5\times9}{4\times6\times10}=\frac{135}{240}=\frac{9}{16};$$

or, $\dfrac{\cancel{3}\times\cancel{5}\times9}{4\times\underset{2}{\cancel{6}}\times\underset{2}{\cancel{10}}}=\frac{9}{16}$, *Answer.*

(*9th.*) Reduce $\frac{4}{5}$ *of* $\frac{6}{8}$ *of* $\frac{7}{9}$ to a simple fraction.

$$\frac{4\times6\times7}{5\times8\times9}=\frac{168}{360}=\frac{7}{15};$$

or, $\dfrac{\cancel{4}\times\overset{\cancel{2}}{\cancel{6}}\times7}{5\times\underset{\cancel{2}}{\cancel{8}}\times\underset{3}{\cancel{9}}}=\frac{7}{15}$, *Answer.*

CASE VI.

To reduce Fractions of different Denominators to equivalent Fractions having a Common Denominator.

Multiply each Numerator by all the Denominators except its own for the new Numerators; and multiply all the Denominators together for a Common Denominator.

NOTE.—It is evident that in this and several other operations, when any of the proposed quantities are integers or Mixed Numbers, or Compound Fractions, they must first be reduced, by their proper Rules, to the form of Simple Fractions.

EXAMPLES.

(1*st.*) Reduce $\frac{1}{2}$, $\frac{2}{3}$, *and* $\frac{3}{4}$ to a common denominator.

$1 \times 3 \times 4 = 12$ new numerator for $\frac{1}{2}$
$2 \times 2 \times 4 = 16$,, ,, ,, $\frac{2}{3}$
$3 \times 2 \times 3 = 18$,, ,, ,, $\frac{3}{4}$

$2 \times 3 \times 4 = 24$ common denominator;
hence the fractions are $\frac{12}{24}$, $\frac{16}{24}$, *and* $\frac{18}{24}$;
or, by abbreviation, $\frac{6}{12}$, $\frac{8}{12}$, $\frac{9}{12}$, *Answer.*

Second Method :—

Multiply numerator and denominator of $\frac{1}{2}$ by $6 = \frac{6}{12}$
,, ,, ,, $\frac{2}{3}$,, $4 = \frac{8}{12}$
,, ,, ,, $\frac{3}{4}$,, $3 = \frac{9}{12}$

(2*nd.*) Reduce $\frac{2}{7}$ *and* $\frac{5}{9}$ to fractions of a common denominator.

$2 \times 9 = 18$ new numerator for $\frac{2}{7}$
$5 \times 7 = 35$,, ,, ,, $\frac{5}{9}$

$7 \times 9 = 63$ common denominator;
hence the new fractions $\frac{18}{63}$ *and* $\frac{35}{63}$, *Answer.*

(3*rd*) Reduce $\frac{2}{3}$, $\frac{3}{5}$, *and* $\frac{3}{4}$ to a common denominator.

$2 \times 5 \times 4 = 40$ new numerator for $\frac{2}{3}$,
$3 \times 3 \times 4 = 36$,, ,, ,, $\frac{3}{5}$,
$3 \times 3 \times 5 = 45$,, ,, ,, $\frac{3}{4}$,

$3 \times 5 \times 4 = 60$ common denominator;
hence the new fractions are $\frac{40}{60}$, $\frac{36}{60}$, *and* $\frac{45}{60}$, *Answer.*

Second Method :—

$$\frac{2}{3} \times 20 = \frac{40}{60},\ \frac{3}{5} \times 12 = \frac{36}{60},\ \text{and}\ \frac{3}{4} \times 15 = \frac{45}{60}.$$

(4*th.*) Reduce $\frac{5}{6}$, $2\frac{3}{5}$, *and* 4 to a common denominator.

First by Case II., $5 \times 5 \times 1 = 25$ new numerator for $\frac{5}{6}$,
$6 \times 13 \times 1 = 78$,, ,, ,, $\frac{13}{5}$,
$4 \times 6 \times 5 = 120$,, ,, ,, $\frac{4}{1}$,

$6 \times 5 \times 1 = 30$ common denominator;

$$\begin{array}{r} 2\frac{3}{5} \\ 5 \\ \hline 13 \\ \hline 5 \end{array}$$

hence the new fractions are $\frac{25}{30}$, $\frac{78}{30}$, *and* $\frac{120}{30}$, *Answer.*

Second Method:—

$$\frac{5}{6} \times 5 = \frac{25}{30};\ \frac{13}{5} \times 6 = \frac{78}{30};\ \frac{4}{1} \times 30 = \frac{120}{30}.$$

(*5th.*) Reduce $\frac{1}{2}$, $\frac{3}{4}$, *and* $\frac{5}{8}$ to a common denominator.

$1 \times 4 \times 8 = 32$ new numerator for $\frac{1}{2}$
$3 \times 2 \times 8 = 48$ „ „ „ $\frac{3}{4}$
$5 \times 2 \times 4 = 40$ „ „ „ $\frac{5}{8}$

$2 \times 4 \times 8 = 64$ common denominator.
hence the new fractions are $\frac{32}{64}$, $\frac{48}{64}$, $\frac{40}{64}$;
or, by abbreviation, $\frac{4}{8}$, $\frac{6}{8}$, $\frac{5}{8}$, *Answer.*

(*6th.*) Reduce $\frac{7}{8}$, $\frac{2}{3}$, $\frac{3}{5}$, *and* $\frac{6}{7}$ to a common denominator.

$7 \times 3 \times 5 \times 7 = 735$ new numerator for $\frac{7}{8}$
$2 \times 8 \times 5 \times 7 = 560$ „ „ „ $\frac{2}{3}$
$3 \times 8 \times 3 \times 7 = 504$ „ „ „ $\frac{3}{5}$
$6 \times 8 \times 3 \times 5 = 720$ „ „ „ $\frac{6}{7}$

$8 \times 3 \times 5 \times 7 = 840$ common denominator;
hence the new fractions are $\frac{735}{840}$, $\frac{560}{840}$, $\frac{504}{840}$, $\frac{720}{840}$, *Answer.*

(*7th.*) Reduce $\frac{3}{5}$, $\frac{1}{2}$, $\frac{1}{7}$, *and* $\frac{1}{3}$ to a common denominator.

$3 \times 2 \times 7 \times 3 = 126$ new numerator for $\frac{3}{5}$
$1 \times 5 \times 7 \times 3 = 105$ „ „ „ $\frac{1}{2}$
$1 \times 5 \times 2 \times 3 = 30$ „ „ „ $\frac{1}{7}$
$1 \times 5 \times 2 \times 7 = 70$ „ „ „ $\frac{1}{3}$

$5 \times 2 \times 7 \times 3 = 210$ common denominator;
hence the new fractions are $\frac{126}{210}$, $\frac{105}{210}$, $\frac{30}{210}$, $\frac{70}{210}$, *Answer.*

(*8th.*) Reduce $\frac{4}{5}$, $\frac{2}{3}$, $\frac{3}{7}$, *and* $\frac{1}{8}$ to a common denominator.

$4 \times 3 \times 7 \times 8 = 672$ new numerator for $\frac{4}{5}$
$2 \times 5 \times 7 \times 8 = 560$ „ „ „ $\frac{2}{3}$
$3 \times 5 \times 3 \times 8 = 360$ „ „ „ $\frac{3}{7}$
$1 \times 5 \times 3 \times 7 = 105$ „ „ „ $\frac{1}{8}$

$5 \times 3 \times 7 \times 8 = 840$ common denominator;
hence the new fractions are $\frac{672}{840}$, $\frac{560}{840}$, $\frac{360}{840}$, $\frac{105}{840}$, *Answer.*

(9*th.*) Reduce $\frac{1}{3}$, $\frac{5}{9}$, $\frac{1}{4}$, *and* $\frac{3}{5}$ to a common denominator.

$1 \times 9 \times 4 \times 5 = 180$ new numerator for $\frac{1}{3}$
$5 \times 3 \times 4 \times 5 = 300$ " " " $\frac{5}{9}$
$1 \times 3 \times 9 \times 5 = 135$ " " " $\frac{1}{4}$
$3 \times 3 \times 9 \times 4 = 324$ " " " $\frac{3}{5}$

$3 \times 9 \times 4 \times 5 = 540$ common denominator.

Hence the new fractions are $\frac{180}{540}$, $\frac{300}{540}$, $\frac{135}{540}$, $\frac{324}{540}$, *Answer.*

NOTE I.—When the Denominators of two given fractions have a Common Measure, let them be divided by it; then multiply the terms of each by the quotient arising from the other Denominator.

Ex., $\frac{3}{25}$, *and* $\frac{4}{35} = \frac{21}{175}$, *and* $\frac{20}{175}$, by multiplying the former by 7 and the latter by 5.

II.—When the less Denominator of two fractions exactly divides the greater, multiply the terms of that which has the less Denominator by the quotient.

Ex., $\frac{3}{7}$ *and* $\frac{5}{14}$, $= \frac{6}{14}$ *and* $\frac{5}{14}$, by multiplying the former by 2.

III.—When more than two fractions are proposed, it is sometimes convenient first to reduce two of them to a Common Denominator, then these, and a third, and so on till they be all reduced to their Least Common Denominator.

Ex., $\frac{2}{3}$ *and* $\frac{3}{4}$ *and* $\frac{7}{8} = \frac{2}{3}$ *and* $\frac{6}{8}$ *and* $\frac{7}{8} = \frac{16}{24}$ *and* $\frac{18}{24}$ *and* $\frac{21}{24}$.

* * *

CASE VII.

To reduce Complex Fractions to Single ones.

Reduce the two parts both to simple fractions, then multiply the Numerator of each by the Denominator of the other, which is in fact only increasing each part by equal multiplications, which makes no difference in the value of the whole.

So, $\dfrac{\frac{5}{2}}{3} = \frac{5}{6}$; and $\dfrac{2\frac{1}{3}}{4} = \frac{7}{12}$: also, $\dfrac{3\frac{2}{5}}{4\frac{1}{2}} = \dfrac{\frac{17}{5}}{9} = \frac{34}{45}$;

CASE VIII.

To find the Value of a Fraction in Parts of the Integer.

Multiply the integer by the Numerator, and divide the product by the Denominator by Compound Multiplication and Division, if the integer be a compound quantity; or if it be a single integer, multiply the Numerator by the parts in the next inferior denomination, and divide the product by the Denominator; then if any remains, multiply it by the parts in the next inferior denomination, and divide the Denominator as before, and so on as far as necessary; so shall the quotients, placed in order, be the value of the fractions required.

EXAMPLES.

(1*st.*) Find the value of $\frac{3}{8}$ of a £ sterling.

$$\begin{array}{r|l} & 3 \\ & \underline{20} \\ 8 & \underline{60} \\ & 7s.\ 6d. \end{array}$$

Answer.

(2*nd.*) What is the value of $\frac{2}{9}$ of a guinea?

$$\begin{array}{r|l} & 2 \\ & \underline{21} \\ 9 & \underline{42} \\ & 4s.\ 8d. \end{array}$$

Answer.

(3*rd.*) What is the value of $\frac{3}{4}$ of a half-crown?

$$\begin{array}{r|l} & s.\ d. \\ & 2 \cdot 6 = \textit{half a crown.} \\ & \underline{3} \\ 4 & \underline{7 \cdot 6} \\ & 1s.\ 10\tfrac{1}{2}d. \end{array}$$

Answer.

(4*th.*) What is the value of $\frac{2}{5}$ of 4*s.* 10*d.*?

s. *d.*
4 · 10
2
5 | 9 · 8.
1*s.* 11 $\frac{1}{5}$*d.*, *Answer.*

(5*th.*) What is the value of $\frac{4}{5}$ of a pound, Troy?

4
12
5 | 48
9 *oz.* 12 *dwts.*, *Answer.*

(6*th.*) What is the value of $\frac{5}{16}$, of a *cwt.*?

5
4
16 | 20
1 *qr.* 7 *lbs.*, *Answer.*

(7*th.*) What is the value of $\frac{7}{8}$ of an acre?

7
4
8 | 28
3 *rds.* 20 *pls.*, *Answer.*

(8*th.*) What is the value of $\frac{3}{10}$ of a day.

3
24
10 | 72
7 *hrs.*, 12 *min.*, *Answer.*

(9*th.*) Reduce $\frac{2}{5}$ of a shilling to its proper quantity.

2
12
5 | 24
4*s.* $3\frac{1}{5}$*d.*, *Answer.*

(10*th.*) Reduce $\frac{4}{7}$ of a *lb.* Avoirdupois to its proper quantity.

4
16
7 | 64
9 *oz.* $2\frac{2}{7}$ *drs.*, *Answer.*

(11*th.*) Reduce $\frac{5}{9}$ of an English ell to its proper quantity.

5
5
9 | 25
2 *qrs.* $3\frac{1}{9}$ *nls.*, *Answer.*

(12*th.*) Reduce $\frac{4}{5}$ of a mile to its proper quantity.

4
8
5 | 32
6 *fur.* 16 *pls.*, *Answer.*

(13*th.*) Reduce $\frac{6}{7}$ of a hogshead of wine to its proper quantity.

6
63
7 | 378
54 *gals.*, *Answer.*

(14*th.*) Reduce $\frac{3}{9}$ of a barrel of beer to its proper quantity.

$$\begin{array}{r|l} & 3 \\ & \underline{36} \\ 9 & \underline{108} \\ & 12 \text{ gals., } \textit{Answer.} \end{array}$$

(15*th.*) Reduce $\frac{5}{12}$ of a chaldron of coal to its proper quantity.

$$\begin{array}{r|l} & 5 \\ & \underline{36} \\ 12 & \underline{180} \\ & 15 \text{ bshls., } \textit{Answer.} \end{array}$$

(16*th.*) Reduce $\frac{3}{5}$ of a month to its proper quantity.

$$\begin{array}{r|l} & 3 \\ & \underline{4} \\ 5 & \underline{12} \\ & 2w.\ 2d.\ 19h.\ 12m., \textit{ Answer.} \end{array}$$

CASE IX.

To reduce a Fraction from one Denomination to another.

Consider how many of the less denomination make one of the greater; then multiply the Numerator by that number if the reduction be to a less name, but multiply the Denominator if to a greater.

Examples.

(1*st.*) Reduce $\frac{2}{15}$ of a £ to the fraction of a penny.

$$\frac{2 \times 20 \times 12}{15 \times 1 \times 1} = \frac{480}{15} = \frac{32}{1}, \textit{ Answer.}$$

(2*nd.*) Reduce $\frac{2}{7}$ of a farthing to the fraction of a £.

$$\frac{2 \times 1 \times 1 \times 1}{7 \times 4 \times 12 \times 20} = \frac{2}{4800} = \frac{1}{2400}, \textit{ Answer.}$$

(3*rd.*) Reduce $\frac{2}{7}$ of a *cwt.* to the fraction of a *lb.*

$$\frac{2 \times 4 \times 28}{7 \times 1 \times 1} = \frac{224}{7} = \frac{32}{1}, \textit{ Answer.}$$

(4*th.*) Reduce $\frac{3}{5}$ *dwt.* to the fraction of a *lb.* Troy.

$$\frac{3 \times 1 \times 1}{5 \times 20 \times 12} = \frac{3}{1200} = \frac{1}{400}, \textit{ Answer.}$$

(5*th.*) Reduce $\frac{3}{8}$ of a crown to the fraction of a guinea.

$$\frac{3 \times 5}{8 \times 1} = \frac{15}{8} \times \frac{1}{21} = \frac{15}{168} = \frac{5}{56}, \textit{ Answer.}$$

(6*th.*) Reduce $\frac{5}{6}$ of a half-crown to the fraction of a guinea.

$$\frac{5 \times 30}{6 \times 1} = \frac{150}{6} \times \frac{1}{12} = \frac{150}{72} = \frac{25}{18}, \textit{ Answer.}$$

(7*th.*) Reduce 2*s.* 6*d.* to the fraction of a £.

$$\frac{2 \times 12 + 6}{1 \times 20 \times 12} = \frac{30}{240} = \frac{1}{8} \text{ of a £.}, \textit{ Answer.}$$

(8*th.*) Reduce 17*s.* 7*d.* $3\frac{3}{5}$ *qr.* to the fraction of a £.

$$\frac{17 \times 12 + 7 = 211 \times 4 + 3 = 847 \times 5 + 3}{1 \times 20 \times 12 \times 4 \times 5}$$

$$= \frac{4238}{4800} = \frac{2119}{2400} \text{ of a £.}, \textit{ Answer.}$$

(9*th.*) Reduce $\frac{2}{3}$ *cks.* to the fraction of a maund.

$$\frac{2 \times 1 \times 1}{3 \times 16 \times 40} = \frac{2}{1920} = \frac{1}{960} \text{ of a } \textit{md.}, \textit{ Answer.}$$

(10*th.*) Reduce 12 *as.* 8 *pies* to the fraction of a gold mohur.

as.	*pie.*	
		1
12 ·	8	16
12		16
144		16
8		256
152 *pie*		12
		3072

hence the fraction is $\frac{152}{3072} = \frac{19}{384}$ of a *g. m.*, *Answer.*

Or, $\frac{12 \times 12 + 8 \times 1}{1 \times 16 \times 16 \times 12} = \frac{152}{12} = \frac{152}{3072} = \frac{19}{384}$.

(11*th.*) Reduce $\frac{4}{7}$ of a pie to the fraction of a rupee.

$\frac{4 \times 1 \times 1}{7 \times 12 \times 16} = \frac{4}{1344} = \frac{1}{336}$ rupee, *Answer.*

(12*th.*) Reduce 2 seers, 8¼ cks. to the fraction of a maund.

seers.	*cks.*	
		1
2	8¼	40
16		40
40		16
4		640
161		4
		2560

hence the fraction is $\frac{161}{2560}$, *Answer.*

Or, $\frac{2 \times 16 + 8 = 40 \times 4 + 1}{1 \times 40 \times 16 \times 4} = \frac{161}{2560}$;

(13*th.*) Reduce $\frac{1}{3}$ of an ell English to the fraction of a French ell.

$\frac{1 \times 5}{3 \times 6} = \frac{5}{18}$, *Answer.*

Or, ell E. $\frac{1}{3} \times \frac{5}{1} = 5 = \frac{5}{3} \times \overset{qrs.}{6} = \frac{5}{18}$ of an ell French.

(14*th.*) Reduce 6*s.* 8½*d.* to the fraction of a £.

$$\begin{array}{r} s.\ \ d. \\ 6\cdot8\frac{1}{2} \\ 12 \\ \hline 80 \\ 4 \\ \hline 322 \end{array} \qquad\qquad \begin{array}{r} 1 \\ 20 \\ \hline 20 \\ 12 \\ \hline 240 \\ 4 \\ \hline 960 \end{array}$$

hence the fraction is $\frac{322}{960} = \frac{161}{480}$ of a £, *Answer.*

$$\text{Or, } \frac{6\times12+8=80\times4+\frac{1}{2}}{1\times20\times12\times4} = \frac{322}{960} = \frac{161}{480};$$

(15*th.*) Reduce 4½*d.* to the fraction of a shilling.

$$\begin{array}{r} d. \\ 4\frac{1}{2} \\ 4 \\ \hline 18 \end{array} \qquad\qquad \begin{array}{r} 1 \\ 12 \\ \hline 12 \\ 4 \\ \hline 48 \end{array}$$

hence the fraction is $\frac{18}{48} = \frac{3}{8}$ of a shilling, *Answer.*

$$\text{Or, } \frac{4\times4+2=18}{1\times12\times4} = \frac{8}{48} = \frac{3}{8};$$

(16*th.*) Reduce £ 2 · 17*s.* 7⅕*d.* to the fraction of £ 3 · 12*s.*

$$\begin{array}{r} \pounds\ \ s.\ \ d. \\ 2\cdot17\cdot7\frac{1}{5} \\ 20 \\ \hline 57 \\ 12 \\ \hline 691 \\ 5 \\ \hline 3456 \end{array} \qquad\qquad \begin{array}{r} 3 \\ 20 \\ \hline 60 \\ 12 \\ \hline 72 \\ 12 \\ \hline 864 \\ 5 \\ \hline 4320 \end{array}$$

hence the fraction is $\frac{3456}{4320} = \frac{4}{5}$, *Answer.*

$$\text{Or, } \frac{2\times20+17=57\times12+7\ \times5+1}{3\times20+12=72\times12\ \times5} = \frac{3456}{4320} = \frac{4}{5};$$

(17*th*.) Reduce 8*s*. 2*d*. to the fraction of a guinea.

$$\begin{array}{r} \textit{s.}\quad \textit{d.} \\ 8 \cdot 2 \\ \underline{12} \\ 98 \end{array} \qquad\qquad \begin{array}{r} 1 \\ \underline{21} \\ 21 \\ \underline{12} \\ 252 \end{array}$$

hence the fraction is $\frac{98}{252} = \frac{7}{18}$, *Answer.*

Or, $\frac{8 \times 12 + 2 = 98}{1 \times 21 \times 12} = \frac{98}{252} = \frac{7}{18}$;

(18*th*.) Reduce 6 *oz*. 17 *dwts*. 21 *qrs*. to the fraction of a *lb*. Troy.

$$\begin{array}{r} \textit{oz.}\quad \textit{dwts.}\quad \textit{qrs.} \\ 6 \cdot 17 \cdot 21 \\ \underline{20} \\ 137 \\ \underline{24} \\ 3309 \end{array} \qquad\qquad \begin{array}{r} 1 \\ \underline{12} \\ 12 \\ \underline{20} \\ 240 \\ \underline{24} \\ 960 \\ \underline{480} \\ 5760 \end{array}$$

hence the fraction is $\frac{3309}{5760} = \frac{1103}{1920}$, *Answer.*

(19*th*.) Reduce 3 *qrs*. 3 *lbs*. 1 *oz*. $12\frac{5}{9}$ *drs*. to the fraction of a *cwt*.

$$\begin{array}{r} \textit{qrs.}\ \textit{lbs.}\ \textit{oz.}\ \textit{qrs.}\ \textit{drs.} \\ 3 \cdot 3 \cdot 1 \cdot 12\frac{5}{9} \\ \underline{28} \\ 87 \\ \underline{16} \\ 1393 \\ \underline{16} \\ 22300 \\ \underline{9} \\ 200705 \end{array} \qquad\qquad \begin{array}{r} \textit{cwt.} \\ 1 \\ \underline{4} \\ 4 \\ \underline{28} \\ 112 \\ \underline{16} \\ 1792 \\ \underline{16} \\ 28672 \\ \underline{9} \\ 258048 \end{array}$$

hence the fraction is $\frac{200705}{258048}$ *cwt.*, *Answer.*

$$\text{Or, } \frac{3 \times 28 + 3 = 87 \times 16 + 1 = 1393 \times 16 + 12}{1 \times 4 \times 28 \times 16 \times 16 \times 9}$$

$$= \frac{22300 \times 9 + 5}{} = \frac{200705}{258048}.$$

(20*th.*) Reduce 10 *cwt.* 18 *lbs.* $1\frac{1}{31}$ *oz.* to the fraction of a ton.

cwt. *lbs.* *oz.*	20
10 — 18 — $1\frac{1}{31}$	4
4	80
40	28
28	2240
338	16
80	35840
1138	31
16	35840
18209	107520
31	1111040
18210	
54627	
564480	

hence the fraction is $\frac{564480}{1111040} = \frac{63}{124}$ ton, *Answer.*

(21*st.*) Reduce $3\frac{1}{8}$ *qrs.* to the fraction of an ell English.

qrs.	1
$3\frac{1}{8}$	5
8	5
25	8
	40

hence the fraction is $\frac{25}{40} = \frac{5}{8}$ *e.* E., *Answer.*

$$\text{Or, } \frac{3 \times 8 + 1 = 25}{1 \times 5 \times 8} = \frac{25}{40} = \frac{5}{8}$$

(22*nd.*) Reduce 2 feet 6 inches to the fraction of a yard.

feet in.	1
2 — 6	3
12	3
30	12
	36

hence the fraction is $\frac{30}{36} = \frac{5}{6}$, *Answer.*

Or, $\frac{2 \times 12 + 6}{1 \times 3 \times 12} = \frac{30}{36} = \frac{5}{6}$.

(23*rd.*) Reduce 4 furlongs, 32 poles to the fraction of a mile.

fur. poles.	*m. fur.*
4 — 32	1 or 8
40	40
192	320

hence the fraction is $\frac{192}{320} = \frac{3}{5}$, *Answer.*

Or, $\frac{4 \times 40 + 32}{1 \times 8 \times 40} = \frac{192}{320} = \frac{5}{3}$.

(24*th.*) Reduce 3 roods 2 poles to the fraction of an acre.

r. p.	1 *acre* or 4 *roods.*
3 — 2	40
40	160
122	

hence the fraction is $\frac{122}{150} = \frac{61}{80}$, *Answer.*

Or, $\frac{3 \times 40 + 2}{1 \times 4 \times 40} = \frac{122}{160} = \frac{61}{80}$.

(25*th.*) Reduce 42 gallons of wine to the fraction of a hogshead.

$$\frac{42 \times 1}{1 \times 63} = \frac{42}{63} = \tfrac{2}{3}, \textit{ Answer.}$$

(26*th.*) Reduce 28 gallons of beer to the fraction of a barrel.

$$\frac{28 \times 1}{1 \times 36} = \frac{28}{36} = \tfrac{7}{9}, \textit{ Answer.}$$

(27*th.*) Reduce 14 bushels, 2 pecks to the fraction of a chaldron.

$$\begin{array}{r} \textit{b.}\quad \textit{p.} \\ 14 - 2 \\ \underline{4} \\ 58 \end{array} \qquad\qquad \begin{array}{r} 1 \\ \underline{32} \\ 32 \\ \underline{4} \\ 128 \end{array}$$

hence the fraction is $\frac{58}{128} = \tfrac{29}{64}$, *Answer.*

$$\text{Or, } \frac{14 \times 4 + 2}{1 \times 32 \times 4} = \frac{58}{128} = \frac{29}{64}.$$

(28*th.*) Reduce 1 *w.* 3 *d.* 12 *hrs.* to the fraction of a month.

$$\begin{array}{r} \textit{w.}\ \textit{d.}\ \textit{h.} \\ 1 - 3 - 12 \\ \underline{7} \\ 10 \\ \underline{24} \\ 252 \end{array} \qquad\qquad \begin{array}{r} 1 \textit{ month} \text{ or } 4 \textit{ weeks} \\ \underline{7} \\ 28 \\ \underline{24} \\ 672 \end{array}$$

hence the fraction is $\frac{252}{672} = \tfrac{3}{8}$, *Answer.*

$$\text{Or, } \frac{1 \times 7 + 3 = 10 \times 24 + 12}{1 \times 4 \times 7 \times 24} = \frac{252}{172} = \tfrac{3}{8}.$$

ADDITION OF VULGAR FRACTIONS.

If the fractions have a Common Denominator, add all the Numerators together, then place the sum over the Common Denominator and that will be the sum of the fractions required.

If the proposed fractions have not a Common Denominator they must be reduced to one, also Compound Fractions must be reduced to Simple ones, and fractions of different denominations to those of the same denomination: then add the Numerators as before. As to Mixed Numbers, they may either be reduced to Improper Fractions, and so added with the others, or else the fractional parts only added, and the integers united afterwards.

Examples.

(1*st.*) Add $\frac{3}{7}$ and $\frac{6}{7}$ together.

$$\frac{3}{7} + \frac{6}{7} = \frac{9}{7} = 1\tfrac{2}{7}, \textit{ Answer.}$$

(2*nd.*) Add $\frac{3}{4}$ and $\frac{5}{9}$ together.

$$\frac{3}{4} + \frac{5}{9} = \frac{27}{36} + \frac{20}{36} = \frac{47}{36} = 1\tfrac{11}{36}, \textit{ Answer.}$$

(3*rd.*) Add $\frac{2}{7}$ and $\frac{5}{14}$ together.

$$\frac{2}{7} + \frac{5}{14} = \frac{4}{14} + \frac{5}{14} = \tfrac{9}{14};$$

$$\text{or, } 2\left(\frac{2}{7}\right) + \frac{5}{14} = \frac{4}{14} = \frac{4+5}{14} = \tfrac{9}{14}, \textit{ Answer.}$$

(4*th.*) What is the sum of $\frac{2}{3}$ and $\frac{3}{5}$ and $\frac{5}{7}$?

$$\begin{array}{r} 2 \times 5 \times 7 = 70 \\ 3 \times 3 \times 7 = 63 \\ 5 \times 3 \times 5 = 75 \\ \hline 208 \end{array}$$

$$\frac{208}{3 \times 5 \times 7 = 105} = 1\tfrac{103}{105}, \textit{ Answer.}$$

(5*th.*) What is the sum of $\frac{3}{9}$ and $\frac{3}{5}$ and $2\frac{1}{6}$?

$$\begin{array}{r}
5 \times 5 \times 6 = 150 \\
3 \times 9 \times 6 = 162 \\
1 \times 9 \times 5 = 45 \\
\hline
\end{array}$$

$$\frac{357}{9 \times 5 \times 6 = 270} = 1\tfrac{29}{90} + 2 = 3\tfrac{29}{90}, \textit{ Answer.}$$

(6*th.*) What is the sum of $\frac{3}{5}$ and $\frac{4}{5}$ *of* $\frac{1}{3}$, and $9\frac{3}{20}$?

First, (*by Case V.,*) $\frac{4}{5} \times \frac{1}{3} = \frac{4}{15}$;

$$\begin{array}{r}
3 \times 15 \times 20 = 900 \\
4 \times 5 \times 20 = 400 \\
3 \times 15 \times 5 = 225 \\
\hline
\end{array}$$

$$\frac{1525}{5 \times 15 \times 5 = 1500} = 1\tfrac{1}{60} + 9 = 10\tfrac{1}{60};$$

$$\text{or, } \left(\frac{3}{5}\right) + \left(\frac{4}{15}\right)4 + \left(\frac{3}{20}\right)3 = \frac{36}{60} + \frac{16}{60} + \frac{9}{60}$$

$$= \frac{61}{60} = 1\tfrac{1}{60} + 9 = 10\tfrac{1}{60}, \textit{ Answer.}$$

(7*th.*) What is the sum of $\frac{2}{3}$ of a pound and $\frac{5}{9}$ of a shilling?

First, (*by Reduction, Case IX.,*) $\frac{2}{3}$ of a £ $= \frac{2 \times 20}{3} = \frac{40}{3}s.$;

then, (*by the Rule,*) $\frac{40}{3} + \frac{5}{9} = \frac{120}{9} + \frac{5}{9} = \frac{125}{9}$;

or, (*by Case VIII.,*) 13*s.* 10*d.* $2\frac{2}{3}$*qr.*, *Answer.*

(8*th.*) What is the sum of $\frac{3}{5}$ of a shilling and $\frac{4}{15}$ of a penny?

First, (*by Reduction, Case IX.,*) $\frac{3 \times 12}{5 \times 1} \times = \frac{36}{5}$;

then, (*by the Rule,*) $\frac{36}{5} + \frac{4}{15} = \frac{108}{15} + \frac{4}{15} = \frac{112}{15}$;

or, (*by Case VIII.,*) 7*d.* $1\frac{13}{15}$ *qr.*, *Answer.*

(9*th.*) What is the sum of $\frac{1}{7}$ of a £ and $\frac{2}{9}$ of a shilling, and $\frac{5}{12}$ of a penny?

First, (*by Reduction, Case IX.,*) $\frac{1 \times 20}{7 \times 1} = \frac{20}{7}s.$;

$$\left(\frac{20}{7}\ \frac{52}{1449}\right)\ \frac{5}{12} \times \frac{1}{12} = \frac{5}{144};$$

$$\begin{array}{r}
20 \times 9 \times 144 = 25920 \\
2 \times 7 \times 144 = 2016 \\
5 \times 7 \times 9 = 315 \\
\hline
28251 \\
\end{array}$$

$$\frac{28251}{7 \times 9 \times 144 = 9072} = \frac{3139}{1008}s.;$$

or, (*by Case VIII.*) 3*s.* 1*d.* $1\frac{10}{21}$ *qr.*, *Answer.*

(10*th.*) Add $\frac{3}{4}$, $\frac{2}{7}$, and $\frac{5}{6}$ together.

$$\begin{array}{r}
3 \times 7 \times 6 = 126 \\
2 \times 4 \times 6 = 48 \\
5 \times 4 \times 7 = 140 \\
\hline
314 \\
\end{array}$$

$$\frac{314}{4 \times 7 \times 6 = 168} = 1\frac{146}{168} = 1\frac{73}{84};$$

or, first, $\frac{3}{4} + \frac{5}{6} = \frac{9}{12} + \frac{10}{12} = \frac{19}{12}$;

then, $\frac{2}{7} + \frac{9}{12} = \frac{24}{84} + \frac{133}{84} = \frac{157}{84} = 1\frac{73}{84}$, *Answer.*

(11*th.*) Add $\frac{1}{5}$, $4\frac{1}{3}$, and $\frac{2}{5}$ together.

First, $\frac{1}{5} + \frac{2}{5} = \frac{3}{5}$;

then, $\frac{1}{3} + \frac{3}{5} = \frac{5}{15} + \frac{9}{15}$

$= \frac{14}{15} + 4 = 4\frac{14}{15}$, *Answer.*

(12*th.*) Add $7\frac{2}{3}$ and $\frac{2}{5}$ together.

$\frac{2}{3} + \frac{2}{5} = \frac{10}{15} + \frac{6}{15} = \frac{16}{15}$;

$= 1\frac{1}{15} + 7 = 8\frac{1}{15}$, *Answer.*

(13*th.*) Add $\frac{2}{7}$ and $\frac{2}{3}$ *of* $\frac{3}{4}$ together.

$$\text{(First, (\textit{by Case V.},)}\ \frac{\overset{1}{\cancel{2}} \times \cancel{3}}{\cancel{3} \times \underset{2}{\cancel{4}}} = \frac{1}{2};$$

$$\text{then, } \frac{2}{7} + \frac{1}{2} = \frac{4}{14} + \frac{7}{14} = \frac{11}{14}, \textit{ Answer.}$$

(14*th.*) Add $5\frac{2}{3}$, $6\frac{7}{8}$, and $4\frac{1}{2}$ together.

$$\begin{array}{l}
2 \times 8 \times 2 = 32 \\
7 \times 3 \times 2 = 42 \\
1 \times 3 \times 8 = 24 \\
\hline
\phantom{3 \times 8 \times 2 = {}} 98
\end{array}$$

$$\frac{98}{3 \times 8 \times 2 = 48} = 2\frac{2}{48} = 2\frac{1}{24} + 15 = 17\frac{1}{24};$$

$$\text{or first, } \frac{7}{8} + \frac{1}{2} = \frac{7}{8} + \frac{4}{8} = \frac{11}{8};$$

$$\text{then, } \frac{11}{8} + \frac{2}{3} = \frac{33}{24} + \frac{16}{24} = \frac{49}{24} = 2\frac{1}{24};$$

$$\text{and } 5 + 6 + 4 + 2\frac{1}{24} = 17\frac{1}{24}, \textit{ Answer.}$$

(15*th.*) Add $\frac{3}{4}$ of a pound to $\frac{5}{6}$ of a shilling.

$$\frac{3 \times 20}{4 \times 1} = \frac{60}{4} = \frac{15}{1} + \frac{5}{6} = \frac{90}{6} + \frac{5}{6} = \frac{95}{6}\textit{s.};$$

or, (*by Case VIII.*) 15*s.* 10*d.* *Answer.*

(16*th.*) Add $\frac{1}{2}$ of a penny to $\frac{2}{3}$ of a pound.

$$\text{First, } \frac{1 \times 1 \times 1}{2 \times 12 \times 20} = \frac{1}{480};$$

$$\text{then, } \frac{2}{3} + \frac{1}{480} = \frac{320}{480} + \frac{1}{480} = \frac{321}{480};$$

or, 13*s.* 4½*d.*, *Answer.*

(17*th.*) Add $\frac{3}{4}$ of a pound Troy to $\frac{1}{6}$ of an ounce.

$$\text{First, } \frac{3 \times \overset{3}{\cancel{12}}}{\cancel{4} \times 1} = \frac{9}{1}$$

$$\text{then, } \frac{9}{1} + \frac{1}{6} = \frac{54}{6} + \frac{1}{6} = \frac{55}{6}\textit{oz.};$$

or, 9 *oz.* 3 *dwts.* 8 *grs.*, *Answer.*

18*th.*) Add $\frac{4}{5}$ of a ton to $\frac{5}{6}$ of a *lb.*

$$\frac{\cancel{5} \times 1 \times 1}{6 \times 112 \times \underset{4}{\cancel{20}}} = \frac{1}{2688};$$

then, $\frac{4}{5} + \frac{1}{2688} = \frac{10752}{13440} + \frac{5}{13440} = \frac{10757}{13440}$ tons;

or, (*by Case VIII.*) 16 *cwt.*, 13 *oz.*, $5\frac{1}{3}$ *drs.*, *Answer.*

(19*th.*) Add $\frac{2}{3}$ of a chaldron to $\frac{3}{4}$ of a bushel.

First, $\frac{3 \times 1}{4 \times 36} = \frac{3}{144} = \frac{1}{48}$;

then, $\frac{2}{3} + \frac{1}{48} = \frac{32}{48} + \frac{1}{48} = \frac{33}{48}$;

or, (*by Case VIII.,*) 24 *b.* 3 *p.*, *Answer.*

(20*th.*) Add $\frac{1}{6}$ of a yard to $\frac{2}{3}$ of an inch.

First, $\frac{2 \times 1 \times 1}{3 \times 3 \times 12} = \frac{2}{108} = \frac{1}{54}$;

then, $\frac{1}{6} + \frac{1}{54} = \frac{9}{54} + \frac{1}{54} = \frac{10}{54}$;

or, (*by Case VIII.,*) 6 *in.* 2 *bar.*, *Answer.*

(21*st.*) Add $\frac{1}{3}$ of a maund to $\frac{1}{4}$ of a seer.

First, $\frac{1 \times 1}{4 \times 40} = \frac{1}{160}$;

then, $\frac{1}{3} + \frac{1}{160} = \frac{160}{480} + \frac{3}{480} = \frac{163}{480}$;

or, (*by Case VIII.,*) 13 *srs.* $9\frac{1}{3}$ *cks.*, *Answer.*

(22*nd.*) Add $\frac{2}{3}$ of a rupee to $\frac{1}{6}$ of an anna.

First, $\frac{1 \times 1}{6 \times 16} = \frac{1}{96}$;

then, $\frac{2}{3} + \frac{1}{96} = \frac{64}{96} + \frac{1}{96} = \frac{65}{96}$;

or, (*by Case VIII.,*) 10 *as.* 10 *p.*, *Answer.*

SUBTRACTION OF VULGAR FRACTIONS.

PREPARE the fractions the same as for Addition, when necessary; then subtract the one Numerator from the other, and set the Remainder over the Common Denominator for the difference of the fractions sought.

EXAMPLES.

(1*st.*) What is the difference between $\frac{5}{12}$ and $\frac{7}{12}$?

$$\frac{7}{12} - \frac{5}{12} = \frac{2}{12} = \frac{1}{6}, \textit{ Answer.}$$

(2*nd.*) What is the difference between $\frac{3}{13}$ and $\frac{4}{39}$?

$$\frac{3}{13} - \frac{4}{39} = \frac{9}{39} - \frac{4}{39} = \frac{5}{39}, \textit{ Answer.}$$

(3*rd.*) What is the difference between $\frac{5}{12}$ and $\frac{7}{13}$?

$$\frac{7}{13} - \frac{5}{12} = \frac{84}{156} - \frac{65}{156} = \frac{19}{156}, \textit{ Answer.}$$

(4*th.*) What is the difference between $5\frac{3}{8}$ and $\frac{2}{7}$ *of* $4\frac{1}{6}$?

$$\begin{array}{cc} 5\frac{3}{8} & 4\frac{1}{6} \\ 8 & 6 \\ \hline 43 & 25 \\ \hline 8 & 6 \end{array} \qquad \frac{\overset{1}{\cancel{2}} \times 25}{7 \times \underset{3}{\cancel{6}}} = \frac{25}{21};$$

$$\frac{43}{8} - \frac{25}{21} = \frac{903}{168} - \frac{200}{168} = \frac{703}{168} = 4\frac{31}{168}, \textit{ Answer.}$$

(5*th.*) What is the difference between $\frac{5}{9}$ of a pound and $\frac{2}{3}$ *of* $\frac{3}{4}$ of a shilling?

$$\frac{\overset{1}{\cancel{2}} \times \cancel{3}}{\cancel{3} \times \underset{2}{\cancel{4}}} = \frac{1}{2};$$

$$\text{then, } \frac{5 \times 20}{9 \times 1} = \frac{100}{9} - \frac{1}{2} = \frac{200}{18} - \frac{9}{18} = \frac{191}{18}s.;$$

or, (*by Case VIII.*,) 10*s.* 7*d.* $1\frac{1}{3}$ *qr.*, *Answer.*

(*6th.*) What is the difference between $\frac{2}{7}$ *of* $5\frac{1}{6}$ of a pound and $\frac{3}{5}$ of a shilling?

$$\begin{array}{c} 5\frac{1}{6} \\ 6 \\ \hline 31 \\ \hline 6 \end{array};\quad \frac{\overset{1}{\cancel{2}} \times 31}{7 \times \underset{3}{\cancel{6}}} = \frac{31}{21};\quad \frac{3 \times 1}{5 \times 20} = \frac{3}{100};$$

$$\frac{31}{21} - \frac{3}{100} = \frac{3100}{2100} - \frac{63}{2100} = \frac{3037}{2100};$$

or, £1, 8*s.* 11*d.* $\frac{3}{35}$*qr.*, *Answer.*

(*7th.*) From $\frac{5}{6}$ take $\frac{3}{5}$ *of* $\frac{5}{8}$.

$$\frac{3 \times \cancel{5}}{\cancel{5} \times 8} = \frac{3}{8};$$

$$\frac{5}{6} - \frac{3}{8} = \frac{40}{48} - \frac{18}{48} = \frac{22}{48} = \frac{11}{24},\ \textit{Answer.}$$

(*8th.*) From $5\frac{2}{3}$ take $\frac{9}{10}$.

$$\begin{array}{c} 5\frac{2}{3} \\ 3 \\ \hline 17 \\ \hline 3 \end{array};\quad \frac{17}{3} - \frac{9}{10} = \frac{170}{30} - \frac{27}{30} = \frac{143}{30} = 4\frac{23}{30},\ \textit{Answer.}$$

(*9th.*) From $\frac{38}{47}$ take $\frac{3}{5}$.

$$\frac{38}{47} - \frac{3}{5} = \frac{190}{235} - \frac{141}{235} = \frac{49}{235},\ \textit{Answer.}$$

(*10th.*) From $\frac{19}{20}$ take $\frac{1}{7}$ *of* $\frac{2}{3}$.

$$\frac{1 \times 2}{7 \times 3} = \frac{2}{21};$$

$$\text{then, } \frac{19}{20} - \frac{2}{21} = \frac{399}{420} - \frac{40}{420} = \frac{359}{420},\ \textit{Answer.}$$

(*11th.*) From $64\frac{1}{4}$ take $\frac{2}{3}$ *of* $\frac{3}{4}$.

$$\begin{array}{c} 64\frac{1}{4} \\ 4 \\ \hline 257 \\ \hline 4 \end{array};\quad \frac{\overset{1}{\cancel{2}} \times \cancel{3}}{\cancel{3} \times \underset{2}{\cancel{4}}} = \frac{1}{2};$$

$$\frac{257}{4} - \frac{1}{2} = \frac{514}{8} - \frac{4}{8} = \frac{510}{8} = 63\frac{6}{8} = 63\frac{3}{4},\ \textit{Answer.}$$

(12*th.*) From ¾ of a pound take ¾ of shilling.

$$\frac{3\times 1}{4\times 20}=\frac{3}{80};$$

$$\frac{3}{4}-\frac{3}{80}=\frac{240}{320}-\frac{12}{320}=\frac{228}{320}=\frac{57}{80};$$

or, 14*s*. 3*d*., *Answer.*

(13*th.*) From ⅔ of a shilling take ½ of a penny.

$$\frac{1\times 1}{2\times 12}=\frac{1}{24};$$

$$\frac{2}{3}-\frac{1}{24}=\frac{16}{24}-\frac{1}{24}=\frac{15}{24}=\tfrac{5}{8}s.,$$

or, 7½*d*., *Answer.*

(14*th.*) From ¾ of a pound Troy take ⅙ of an ounce.

$$\frac{1\times 1}{6\times 12}=\frac{1}{72};\ \frac{3}{4}-\frac{1}{72}=\frac{54}{72}-\frac{1}{72}=\frac{53}{72};$$

or, (*by Case VIII.*) 8*oz.*, 16*ds.*, 16*gr.*, *Answer.*

(15*th.*) From ⅔ of a chaldron take ¾ of a bushel.

$$\frac{\overset{1}{\cancel{3}}\times 1}{4\times \underset{12}{\cancel{36}}}=\frac{1}{48};$$

$$\frac{2}{3}-\frac{1}{48}=\frac{32}{48}-\frac{1}{48}=\frac{31}{48};$$

or, 23 *bshls.*, 1 *p.*, *Answer.*

(16*th.*) From ⅙ of a yard take ⅔ of an inch.

$$\frac{\overset{1}{\cancel{2}}\times 1\times 1}{3\times \underset{6}{\cancel{12}}\times 3}=\frac{1}{54};$$

$$\frac{1}{6}-\frac{1}{54}=\frac{9}{54}-\frac{1}{54}=\frac{8}{54}=\frac{4}{27};$$

or, 5 *in.*, 1 *b.-corn*, *Answer.*

MULTIPLICATION OF VULGAR FRACTIONS.

Reduce mixed numbers if there be any, to equivalent fractions; then multiply all the numerators together for a numerator, and all the denominators together for a denominator, which will give the product required.

EXAMPLES.

(1*st.*) Required the product of $\frac{2}{7}$ and $\frac{5}{8}$.

$$\frac{\overset{1}{\cancel{2}}}{7} \times \frac{5}{\underset{4}{\cancel{8}}} = \frac{5}{28}, \textit{ Answer.}$$

(2*nd.*) Required the product of $\frac{4}{15}$ and $\frac{5}{24}$.

$$\frac{\overset{1}{\cancel{4}}}{\underset{3}{\cancel{15}}} \times \frac{\overset{1}{\cancel{5}}}{\underset{6}{\cancel{24}}} = \frac{1}{18}, \textit{ Answer.}$$

(3*rd.*) Required the product of $\frac{3}{7}$, $\frac{4}{9}$, and $\frac{14}{15}$.

$$\frac{\cancel{3}}{7} \times \frac{4}{\underset{3}{\cancel{9}}} \times \frac{\overset{2}{\cancel{14}}}{15} = \frac{8}{45}, \textit{ Answer.}$$

(4*th.*) Required the product of $\frac{1}{2}$, $\frac{2}{3}$, and 3.

$$\frac{1}{\cancel{2}} \times \frac{\cancel{2}}{\cancel{3}} \times \frac{\cancel{3}}{1} = \frac{1}{1} = 1, \textit{ Answer.}$$

(5*th.*) Required the product of $\frac{7}{9}$, $\frac{3}{5}$, and $4\frac{5}{14}$.
First, (*by Case II.,*) $4\frac{5}{14}$.

$$\begin{array}{c} 14 \\ \hline 61 \\ \hline 14 \end{array}$$

$$\text{then, } \frac{7}{\underset{3}{\cancel{9}}} \times \frac{\cancel{3}}{5} \times \frac{61}{\underset{2}{\cancel{14}}} = \frac{61}{30} = 2\frac{1}{30}, \textit{ Answer.}$$

(6*th.*) Required the product of $\frac{5}{61}$ and $\frac{2}{3}$ *of* $\frac{6}{7}$.

$$\frac{2}{\cancel{3}} \textit{ of } \frac{\overset{2}{\cancel{6}}}{7} = \frac{4}{7};$$

$$\text{then, } \frac{4}{7} \times \frac{5}{6} = \frac{20}{42} = \frac{10}{21}, \textit{ Answer.}$$

(*7th.*) Required the product of 6 and $\frac{2}{3}$ *of* 5.

(First, (*by Case V.,*) $\frac{2}{3}$ *of* $\frac{5}{1} = \frac{10}{3}$;

$$\text{then, } \frac{10}{3} \times \frac{6}{1} = \frac{60}{3} = 20, \textit{ Answer.}$$

(*8th.*) Required the product of $\frac{2}{9}$ *of* $\frac{3}{5}$ and $\frac{5}{8}$ *of* $3\frac{2}{7}$.

$$\text{First, } \frac{2}{\underset{3}{\cancel{9}}} \times \frac{\cancel{3}}{5} = \frac{2}{15};$$

$$\text{then, } \frac{5}{8} \textit{ of } 3\tfrac{2}{7} = \frac{5}{8} \times \frac{23}{7} = \frac{115}{56};$$

$$\frac{\cancel{2}}{\underset{3}{\cancel{15}}} \times \frac{\overset{23}{\cancel{115}}}{\underset{28}{\cancel{56}}} = \frac{23}{84}, \textit{ Answer.}$$

(*9th.*) Required the product of $3\frac{2}{7}$ and $4\frac{14}{33}$.

$$\begin{array}{r} 3\frac{2}{7} \\ 7 \\ \hline 23 \\ \hline 7 \end{array} \qquad\qquad \begin{array}{r} 4\frac{14}{33} \\ 33 \\ \hline 146 \\ \hline 33 \end{array}$$

$$\frac{23}{7} \times \frac{146}{33} = \frac{3358}{231} = 14\tfrac{124}{231}, \textit{ Answer.}$$

(*10th.*) Required the product of 5, $\frac{2}{3}$, $\frac{2}{7}$ *of* $\frac{3}{5}$, and $4\frac{1}{6}$.

$$\frac{2}{7} \textit{ of } \frac{3}{5} = \frac{6}{35}; \qquad \begin{array}{r} 4\frac{1}{6} \\ 6 \\ \hline 25 \\ \hline 6 \end{array}$$

$$\text{then, } \frac{\cancel{5}}{1} \times \frac{2}{3} \times \frac{\cancel{6}}{\underset{7}{\cancel{35}}} \times \frac{25}{\cancel{6}} = \frac{50}{21};$$

or, $2\frac{8}{21}$, *Answer.*

(11*th.*) Multiply $\frac{7}{9}$ by $\frac{2}{3}$.

$$\frac{7}{9} \times \frac{2}{3} = \tfrac{14}{27}, \textit{ Answer.}$$

(12*th.*) Multiply $48\frac{3}{5}$ by $13\frac{5}{6}$.

$$\begin{array}{r} 48\frac{3}{5} \\ 5 \\ \hline 243 \\ \hline 5 \end{array} \qquad\qquad \begin{array}{r} 13\frac{5}{6} \\ 6 \\ \hline 83 \\ \hline 6 \end{array}$$

$$\frac{243}{5} \times \frac{83}{6} = \frac{20169}{0} = 672\tfrac{9}{30}$$

$$= 672\tfrac{3}{10}, \textit{ Answer.}$$

(13*th.*) Multiply $430\frac{6}{10}$ by $18\frac{3}{7}$.

$$\begin{array}{r} 430\frac{6}{10} \\ 10 \\ \hline 4306 \\ \hline 10 \end{array} \qquad\qquad \begin{array}{r} 18\frac{3}{7}. \\ 7 \\ \hline 129 \\ \hline 7 \end{array}$$

then, $\frac{4306}{10} \times \frac{129}{7} = \frac{555474}{70} = 7935\tfrac{24}{70}$

$$= 7935\tfrac{12}{35}, \textit{ Answer.}$$

(14*th.*) Multiply $\frac{16}{21}$ by $\frac{3}{4}$ *of* $\frac{5}{7}$ *of* $\frac{4}{5}$.

$$\frac{3}{\cancel{4}} \textit{ of } \frac{\cancel{5}}{7} \textit{ of } \frac{\cancel{4}}{\cancel{5}} = \frac{3}{7};$$

then, $\frac{16}{\underset{7}{\cancel{21}}} \times \frac{\cancel{3}}{7} = \tfrac{16}{49}, \textit{ Answer.}$

(15*th.*) Multiply $\frac{9}{10}$ by $\frac{2}{3}$ *of* $\frac{3}{4}$ *of* $\frac{5}{6}$.

$$\frac{\cancel{2}}{3} \textit{ of } \frac{\cancel{3}}{\underset{2}{\cancel{4}}} \textit{ of } \frac{5}{\underset{2}{\cancel{6}}} = \frac{5}{12};$$

$$\frac{9}{\underset{2}{\cancel{10}}} \times \frac{\cancel{5}}{12} = \frac{9}{24} = \tfrac{3}{8}, \textit{ Answer.}$$

(16*th.*) Multiply $\frac{3}{4}$ *of* $\frac{2}{3}$ by $\frac{2}{3}$ *of* $\frac{1}{3}$.

$$\frac{\cancel{3}}{\underset{2}{\cancel{4}}} \text{ of } \frac{\overset{1}{\cancel{2}}}{\cancel{3}} = \frac{1}{2}; \qquad \frac{2}{3} \text{ of } \frac{1}{3} = \frac{2}{9};$$

$$\text{then, } \frac{1}{\cancel{2}} \times \frac{\cancel{2}}{9} = \tfrac{1}{9}, \text{ Answer.}$$

(17*th.*) Multiply $5\frac{6}{7}$ by $\frac{5}{6}$.

$$\begin{array}{c} 5\frac{6}{7} \\ \underline{7} \\ \underline{41} \\ 7 \end{array}; \qquad \frac{41}{7} \times \frac{5}{6} = \frac{205}{42} = 4\tfrac{37}{42}, \text{ Answer.}$$

(18*th.*) Multiply $\frac{1}{4}$ *of* $\frac{3}{8}$ by $\frac{5}{7}$.

$$\frac{1}{4} \text{ of } \frac{3}{8} = \frac{3}{32};$$

$$\text{then, } \frac{5}{7} \times \frac{3}{32} = \tfrac{15}{224}, \text{ Answer.}$$

(19*th.*) Multiply 24 by $\frac{2}{3}$.

$$\frac{\overset{8}{\cancel{24}}}{1} \times \frac{2}{\underset{1}{\cancel{3}}} = \frac{16}{1} = 16, \text{ Answer.}$$

(20*th.*)* Multiply $\frac{3}{4}$ *of* 9 by $\frac{7}{8}$.

$$\frac{3}{4} \text{ of } \frac{9}{1} = \frac{27}{4};$$

$$\text{then, } \frac{7}{8} \times \frac{27}{4} = \frac{189}{32} = 5\tfrac{29}{32}, \text{ Answer.}$$

(21*st.*) Multiply $9\frac{1}{2}$ by $\frac{2}{6}$.

$$\begin{array}{c} 9\frac{1}{2} \\ \underline{2} \\ 19 \\ \hline 2 \end{array}; \qquad \frac{19}{\cancel{2}} \times \frac{\cancel{2}}{6} = \frac{19}{6} = 3\tfrac{1}{6}, \text{ Answer.}$$

DIVISION OF VULGAR FRACTIONS.

PREPARE the fractions as before in Multiplication; then divide the Numerator by the Numerator, and the Denominator by the Denominator if they will exactly divide,—but if not, invert the terms of the Divisor, and multiply the Dividend by it, as in Multiplication.

EXAMPLES.

(1*st.*) It is required to divide $\frac{16}{25}$ by $\frac{4}{5}$.

$$\frac{16}{25} \div \frac{4}{5} = \tfrac{4}{5}, \textit{ Answer.}$$

(2*nd.*) It is required to divide $\frac{7}{16}$ by $\frac{3}{4}$.

$$\frac{7}{16} \div \frac{3}{4} = \frac{7}{\underset{4}{\cancel{16}}} \times \frac{\cancel{4}}{3} = \tfrac{7}{12}, \textit{ Answer.}$$

(3*rd.*) It is required to divide $\frac{14}{9}$ by $\frac{7}{6}$.

$$\frac{14}{9} \div \frac{7}{6} = \frac{\overset{2}{\cancel{14}}}{9} \times \frac{6}{\cancel{7}} = \frac{12}{9} = 1\tfrac{1}{3}, \textit{ Answer.}$$

(4*th.*) It is required to divide $\frac{5}{6}$ by $\frac{15}{7}$.

$$\frac{5}{6} \div \frac{15}{7} = \frac{\cancel{5}}{6} \times \frac{7}{\underset{3}{\cancel{15}}} = \tfrac{7}{18}, \textit{ Answer.}$$

(5*th.*) It is required to divide $\frac{12}{35}$ by $\frac{3}{5}$.

$$\frac{12}{35} \div \frac{3}{5} = \tfrac{4}{7}, \textit{ Answer.}$$

(6*th.*) It is required to divide $\frac{2}{7}$ by $\frac{3}{5}$.

$$\frac{2}{7} \div \frac{3}{5} = \frac{2}{7} \times \frac{5}{3} = \tfrac{10}{21}, \textit{ Answer.}$$

(7*th.*) It is required to divide $\frac{9}{16}$ by 3.

$$\frac{9}{16} \div \frac{3}{1} = \tfrac{3}{16}, \textit{ Answer.}$$

(8*th.*) It is required to divide $\frac{3}{5}$ by 2.

$$\frac{3}{5} \div \frac{2}{1} = \frac{3}{5} \times \frac{1}{2} = \frac{3}{10}, \textit{ Answer.}$$

(9*th.*) It is required to divide $7\frac{1}{3}$ by $9\frac{5}{9}$.

$$\begin{array}{r} 7\frac{1}{3} \\ 3 \\ \hline 22 \\ \hline 3 \end{array} \qquad \begin{array}{r} 9\frac{5}{9}. \\ 9 \\ \hline 86 \\ \hline 9 \end{array}$$

$$\frac{22}{3} \div \frac{86}{9} = \frac{22}{3} \times \frac{9}{86} = \frac{198}{258} = \frac{33}{43}, \textit{ Answer.}$$

(10*th.*) It is required to divide $\frac{2}{3}$ *of* $\frac{1}{3}$ by $\frac{5}{7}$ *of* $7\frac{3}{5}$.

$$\frac{2}{3} \textit{ of } \frac{1}{3} = \frac{2}{9}; \qquad \begin{array}{r} 7\frac{3}{5} \\ 5 \\ \hline 38; \\ \hline 5 \end{array} \qquad \frac{\cancel{5}}{7} \times \frac{38}{\cancel{5}} = \frac{38}{7};$$

$$\frac{2}{9} \div \frac{38}{7} = \frac{2}{9} \times \frac{7}{38} = \frac{14}{342} = \frac{7}{171}, \textit{ Answer.}$$

(11*th.*) Divide $\frac{14}{27}$ by $\frac{2}{3}$.

$$\frac{14}{27} \div \frac{2}{3} = \frac{7}{9}, \textit{ Answer.}$$

(12*th.*) Divide $672\frac{9}{30}$ by $13\frac{5}{6}$.

$$\begin{array}{r} 672\frac{9}{30} \\ 30 \\ \hline 20169 \\ \hline 30 \end{array} \qquad \begin{array}{r} 13\frac{5}{6} \\ 6 \\ \hline 83 \\ \hline 6 \end{array}$$

$$\frac{20169}{30} \div \frac{83}{6} = \frac{243}{5} = 48\frac{3}{5}, \textit{ Answer.}$$

(13*th.*) Divide $7935\frac{24}{70}$ by $18\frac{3}{7}$.

$$\begin{array}{r} 7935\frac{24}{70} \\ 70 \\ \hline 555474 \\ \hline 70 \end{array} \qquad \begin{array}{r} 18\frac{3}{7}. \\ 7 \\ \hline 129 \\ \hline 7 \end{array}$$

$$\frac{555474}{70} \div \frac{129}{7} = \frac{4306}{10} = 430\frac{6}{10};$$

or, $430\frac{3}{5}$, *Answer.*

(14*th.) Divide $\frac{3}{8}$ by $\frac{2}{3}$ *of* $\frac{3}{4}$ *of* $\frac{5}{6}$.

$$\frac{2}{3}\ \textit{of}\ \frac{3}{4}\ \textit{of}\ \frac{5}{6}=\frac{5}{12};$$

$$\frac{3}{8}\div\frac{5}{12}=\frac{3}{8}\times\frac{12}{5}=\frac{36}{40}=\tfrac{9}{10},\ \textit{Answer.}$$

(15*th.*) Divide $\frac{2}{3}$ *of* 16 by $\frac{5}{7}$ *of* $\frac{3}{4}$.

$$\frac{2}{3}\ \textit{of}\ \frac{16}{1}=\frac{32}{3};\quad \frac{5}{7}\ \textit{of}\ \frac{3}{4}=\frac{15}{28};$$

$$\frac{32}{3}\div\frac{15}{28}=\frac{32}{3}\times\frac{28}{15}=\tfrac{896}{45}=19\tfrac{41}{45},\ \textit{Answer.}$$

(16*th.*) Divide $\frac{1}{2}$ *of* $\frac{2}{3}$ by $\frac{2}{3}$ *of* $\frac{3}{4}$.

$$\frac{1}{\cancel{2}}\ \textit{of}\ \frac{\cancel{2}}{3}=\frac{1}{3};\ \frac{\cancel{2}}{3}\ \textit{of}\ \frac{3}{\underset{2}{\cancel{4}}}=\frac{1}{2};$$

$$\frac{1}{3}\div\frac{1}{2}=\frac{1}{3}\times\frac{2}{1}=\tfrac{2}{3},\ \textit{Answer.}$$

(17*th.*) Divide $9\frac{2}{12}$ by $\frac{1}{2}$ *of* 7.

$$\begin{array}{r} 9\tfrac{2}{12} \\ 12 \\ \hline 110 \\ \hline 12 \end{array}\qquad \frac{1}{2}\ \textit{of}\ \frac{7}{1}=\frac{7}{2};$$

$$\frac{110}{12}\div\frac{7}{2}=\frac{110}{12}\times\frac{2}{7}=\frac{220}{84}=2\tfrac{52}{84};$$

$$\text{or, }=2\tfrac{13}{21},\ \textit{Answer.}$$

(18*th.*) Divide $\frac{9}{16}$ by $4\frac{1}{2}$.

$$\begin{array}{r} 4\tfrac{1}{2} \\ 2 \\ \hline 9 \\ \hline 2 \end{array}\qquad \frac{9}{16}\div\frac{9}{2}=\tfrac{1}{8},\ \textit{Answer.}$$

THE RULE OF THREE IN VULGAR FRACTIONS.

MAKE the necessary preparations as before directed, then multiply continually together the second and third Terms, and the first with its parts inverted, as in Division, for the answer.

EXAMPLES.

(*1st.*) What will $3\frac{3}{8}$ *oz.* of silver cost at 6*s.* 4*d.* an ounce?

$$3\tfrac{3}{8}\ (\textit{by Case II.}) = \frac{27}{8};$$

$$\text{second, } 6s.\ 4d. = \frac{6 \times 12 + 4}{20 \times 12} = \frac{76}{240} = \frac{19}{60};$$

$$\textit{As}\ \overset{oz.}{\frac{1}{1}} : \frac{19}{60} :: \frac{27}{8};$$

$$\text{hence, } \frac{1}{1} \times \frac{19}{\underset{20}{\cancel{60}}} \times \frac{\overset{9}{\cancel{27}}}{8} = \frac{171}{160}\ 1\tfrac{11}{160}$$

or, £1 1*s.* $4\frac{1}{2}$*d.*, *Answer.*

(*2nd.*) If $\frac{3}{16}$ of a ship be worth 273*l.* 2*s.* 6*d.*, what are $\frac{5}{32}$ of her worth?

$$273\text{-}2\text{-}6\ (\textit{by Case IX.}) = 273\,\frac{2 \times 12 + 6}{20 \times 12} = 273\tfrac{30}{240}$$

$$= 273\tfrac{1}{8} \text{ and } (\textit{by Case II.}) = \frac{2185}{8};$$

$$\textit{As}\ \frac{3}{16} : \frac{2185}{8} :: \frac{5}{32};$$

$$\text{hence, } \frac{\cancel{16}}{3} \times \frac{2185}{8} \times \frac{5}{\underset{2}{\cancel{32}}} = \frac{10925}{48} = 227\tfrac{29}{48};$$

or, £227 12*s.* 1*d.*, *Answer.*

(3*rd.*) What is the purchase of £1,230 bank stock, at $108\frac{5}{8}$ per cent.?

$$108\tfrac{5}{8}\ (\textit{by Case II.}) = \frac{869}{8};$$

$$\textit{As}\ \frac{100}{1} : \frac{869}{8} :: \frac{1230}{1};$$

$$\text{hence, } \frac{1}{10\cancel{0}} \times \frac{869}{8} \times \frac{123\cancel{0}}{1} = \frac{106887}{80} = 1336\tfrac{7}{80}$$

$$= \pounds1{,}336\ 1s.\ 9d.\ \textit{Answer.}$$

(4*th.*) What is the interest of 273*l.* 15*s.* for a year, at $3\frac{1}{4}$ per cent.?

$$273\,\frac{15\times1}{1\times20} = 273\tfrac{15}{20} = 273\tfrac{3}{4}, \text{ and } (\textit{by Case II.})\ \frac{1095}{4};$$

$$\textit{As}\ \frac{100}{1} : \frac{13}{4} :: \frac{1095}{4};$$

$$\text{hence, } \frac{1}{\underset{20}{\cancel{100}}} \times \frac{13}{4} \times \frac{\overset{219}{\cancel{1095}}}{4} = \frac{2847}{320}; = 8\tfrac{287}{320}$$

$$= \pounds8\ 17s.\ 11\tfrac{1}{4}d.,\ \textit{Answer.}$$

(5*th.*) If $\frac{1}{8}$ of a ship be worth 73*l.* 1*s.* 3*d.*, what part of her is worth 250*l.* 10*s.*?

$$73\,\frac{1\times12+3}{1\times20\times12} = 73\,\frac{15}{240} = 73\tfrac{1}{16} = \frac{1169}{16},\ (\textit{by Case II.});$$

$$250\,\frac{\overset{1}{\cancel{10}}\times1}{1\times\underset{2}{\cancel{20}}} = \frac{1}{2} + 250 = 250\tfrac{1}{2} = \frac{501}{2},\ (\textit{by Case II.});$$

$$\textit{As}\ \frac{1169}{16} : \frac{1}{8} :: \frac{501}{2};$$

$$\text{hence, } \frac{\overset{\cancel{2}}{\cancel{16}}}{1169} \times \frac{1}{\cancel{8}} \times \frac{501}{\cancel{2}} = \frac{501}{1169} = \tfrac{3}{7},\ \textit{Answer.}$$

(6*th*.) What length must be cut off a board that is $7\frac{3}{4}$ inches broad, to contain a square foot, or as much as another piece of 12 inches long and 12 broad?

$7\frac{3}{4} = \frac{31}{4}$, (*by Case II.*);

$$As\ \overset{in.}{\frac{12}{1}} : \overset{in.}{\frac{12}{1}} :: \overset{in.}{\frac{31}{4}},\ (inverse);$$

$$hence,\ \frac{12}{1} \times \frac{12}{1} \times \frac{4}{31} = \frac{576}{31} = 18\frac{18}{31}\ in.,\ Answer.$$

(7*th*.) What quantity of shalloon that is $\frac{3}{4}$ of a yard wide will line $9\frac{1}{2}$ yards of cloth that is $2\frac{1}{2}$ yards wide?

$9\frac{1}{2} yds. = \frac{19}{2}$, (*by Case II.*); $2\frac{1}{2}\ yds. = \frac{5}{2}$,

$$As\ \frac{5}{2} : \frac{19}{2} :: \frac{3}{4},\ (inverse);$$

$$hence,\ \frac{5}{\cancel{2}} \times \frac{19}{\cancel{2}} \times \frac{\overset{\cancel{2}}{\cancel{4}}}{3} = \frac{95}{3} = 31\frac{2}{3},\ Answer.$$

(8*th*.) If the penny loaf weigh $6\frac{9}{10}$ *oz.*, when the price of wheat is 5*s*. the bushel, what ought it to weigh when the wheat is 8*s*. 6*d*. the bushel?

$6\frac{9}{10} = \frac{69}{10}$, (*by Case II.*); 8*s*. 6*d*. $= 8\frac{6}{12}$, or $8\frac{1}{2} = \frac{17}{2} s.$

$$As\ \frac{5}{1} : \frac{69}{10} :: \frac{17}{2},\ (inverse);$$

$$hence,\ \frac{\cancel{5}}{1} \times \frac{69}{\underset{\cancel{2}}{\cancel{10}}} \times \frac{\cancel{2}}{17} = \frac{69}{17} = 4\frac{1}{17}\ oz.,\ Answer.$$

(9*th*.) How much in length of a piece of land that is $11\frac{11}{12}$ poles broad will make an acre of land, or as much as 40 poles in length and 4 in breadth?

$11\frac{11}{12} = \frac{143}{12}$ (*by Case II.*);

$$As\ \frac{4}{1} : \frac{40}{1} :: \frac{143}{12};$$

$$hence,\ \frac{4}{1} \times \frac{40}{1} \times \frac{12}{143} = \frac{1920}{143} = 13\frac{61}{143},\ Answer.$$

(10*th.*) If a courier perform a certain journey in $35\frac{1}{2}$ days, travelling $13\frac{5}{8}$ hours a day, how long would he be performing the same travelling only $11\frac{9}{10}$ hours a day?

(*By Case II.;*) $35\frac{1}{2} = \frac{71}{2}$; $13\frac{5}{8} = \frac{109}{8}$; and $11\frac{9}{10} = \frac{119}{10}$;

As $\frac{109}{8} : \frac{71}{2} :: \frac{119}{10}$;

hence, $\frac{109}{8} \times \frac{71}{\cancel{2}} \times \frac{\overset{5}{\cancel{10}}}{119} = \frac{38695}{952} = 40\frac{615}{952}$, *Answer.*

(11*th.*) A regiment of soldiers, consisting of 976 men, are to be new clothed, each coat to contain $2\frac{1}{2}$ yards of cloth that is $1\frac{5}{8}$ yard wide, and lined with shalloon $\frac{7}{8}$ yard wide; how many yards of shalloon will line them?

Here $2\frac{1}{2} = \frac{5}{2}$;

and $\frac{\overset{488}{\cancel{976}}}{1} \times \frac{5}{\cancel{2}} = \frac{2440}{1}$ *yds.* of cloth for 976 men.

As $\frac{13}{8} : \frac{2240}{1} :: \frac{7}{8}$;

hence, $\frac{13}{\cancel{8}} \times \frac{2440}{1} \times \frac{\cancel{8}}{7} = \frac{\overset{yds.}{31720}}{7} = 4531\frac{3}{7}$;

or, 453 *yds.*, 1 *qr.* $2\frac{6}{7}$ *nls.*, *Answer.*

(12*th.*) If $\frac{5}{6}$ of a yard cost $\frac{2}{3}$ of £1, what will $\frac{11}{12}$ of a yard cost?

As $\frac{\overset{yds.}{5}}{6} : \frac{\overset{£.}{2}}{3} :: \frac{\overset{yds.}{11}}{12}$;

hence, $\frac{\cancel{6}}{5} \times \frac{\cancel{2}}{3} \times \frac{11}{\underset{\cancel{2}}{\cancel{12}}} = \frac{11}{15}$ £, or 14*s.* 8*d.*, *Answer.*

(13*th.*) If $\frac{3}{4}$ of a yard of lawn cost 7*s.* 3*d.*, what will $10\frac{1}{3}$ yards cost?

$$\overset{s.}{7}\text{—}\overset{d.}{3} = \frac{7 \times 12 + 3}{20 \times 12} = \frac{87}{240} = \frac{29}{80}\,£;$$

$$10\tfrac{1}{3}\,yds. = \frac{31}{3},\ (\textit{by Case II.});$$

$$As\ \frac{3}{4} : \frac{29}{80} :: \frac{31}{3};$$

$$\text{hence, } \frac{\cancel{4}}{3} \times \frac{29}{\underset{20}{\cancel{80}}} \times \frac{31}{3} = \frac{899}{180} = 4\tfrac{179}{180}$$

$$= £4\ 19s.\ 10\tfrac{12}{18}d., \textit{ Answer.}$$

(14*th.*) If $\frac{7}{8}$ *lb.* cost $\frac{3}{4}$*s.*, how many pounds will $\frac{8}{9}$ of 1*s.* buy?

$$As\ \frac{3}{4} : \frac{7}{8} :: \frac{8}{9};$$

$$\text{hence, } \frac{4}{3} \times \frac{7}{\cancel{8}} \times \frac{\cancel{8}}{9} = \frac{28}{27} = 1\tfrac{1}{27}\ lb., \textit{ Answer.}$$

(15*th.*) If $\frac{3}{5}$ ell of holland cost $\frac{1}{3}$ of £1, what will $12\frac{2}{3}$ ells cost at the same rate?

$$12\tfrac{2}{3} = \frac{38}{3},\ (\textit{by Case II.});$$

$$As\ \frac{3}{5} : \frac{1}{3} :: \frac{38}{3};$$

$$\text{hence, } \frac{5}{3} \times \frac{1}{3} \times \frac{38}{3} = \frac{190}{27} = 7\tfrac{1}{27}\,£;$$

$$\text{or, } £7\ 0s.\ 8d.\ 3\tfrac{5}{9}qr., \textit{ Answer.}$$

(16*th.*) If $12\frac{1}{2}$ yards of cloth cost 15*s.* 9*d.*, what will $48\frac{1}{4}$ cost at the same rate?

$$(\textit{By Case II.},)\ 12\tfrac{1}{2} = \frac{25}{2};\ 48\tfrac{1}{4} = \frac{193}{4};$$

$$\text{and } \frac{15 \times 12 + 9}{1 \times 20 \times 12} = \frac{189}{240} = \frac{63}{80}\,£;$$

$$As\ \frac{25}{2} : \frac{63}{80} :: \frac{193}{4};$$

$$\text{hence, } \frac{\cancel{2}}{25} \times \frac{63}{80} = \frac{193}{\underset{2}{\cancel{4}}} = \frac{12159}{4000}\,£, = 3\tfrac{159}{4000}\,£;$$

$$\text{or, } £3\ 0s.\ 9d.\ 2\tfrac{4}{25}\ qr., \textit{ Answer.}$$

(17*th*) If $\frac{9}{10}$ of a *cwt.* cost 284*s.* what will $7\frac{1}{2}$ *cwt.* cost at the same rate?

$$7\tfrac{1}{2} = \frac{15}{2} \text{ (\textit{by Case II.})};$$

$$\textit{As } \frac{9}{10} : \frac{284}{1} :: \frac{15}{2};$$

$$\text{hence, } \frac{\overset{5}{\cancel{10}}}{\underset{3}{\cancel{9}}} \times \frac{284}{1} \times \frac{\overset{5}{\cancel{15}}}{\cancel{2}} = \frac{7100}{3} = 2336\tfrac{2}{3}$$

$$= £118\ 6s.\ 8d., \textit{ Answer.}$$

Or, by a Second Method:—

$$\textit{As } \frac{9}{10} : \frac{71}{5} :: \frac{15}{2};$$

$$\frac{\cancel{10}}{\underset{3}{\cancel{9}}} \times \frac{71}{\cancel{5}} \times \frac{\overset{5}{\cancel{15}}}{\cancel{2}} = \frac{355}{3} = 118\tfrac{1}{3};$$

$$\text{or, } 284s. = \frac{284}{20} = \tfrac{71}{5}\ £.$$

(18*th.*) If 3 yards of broad-cloth cost $£2\frac{4}{5}$, what will $10\frac{2}{7}$ yards cost?

$$2\tfrac{4}{5} = \frac{14}{5} \text{ (\textit{by Case II.})};\ 10\tfrac{2}{7} = \frac{72}{7}, \text{ (\textit{by Case II.})};$$

$$\textit{As } \frac{3}{1} : \frac{14}{5} :: \frac{72}{7};$$

$$\text{hence, } \frac{1}{\cancel{3}} \times \frac{\overset{2}{\cancel{14}}}{5} \times \frac{\overset{24}{\cancel{72}}}{\cancel{7}} = \frac{48}{5} = 9\tfrac{3}{5}$$

$$= £9.\ 12s., \textit{ Answer.}$$

(19*th.*) If $\frac{1}{4}$ of a yard cost $\frac{2}{3}$ of £1, what will $\frac{3}{5}$ of an ell English come to at the same rate?

$$\tfrac{3}{5} \textit{ e. E.} = \frac{\overset{1}{\cancel{3}} \times \cancel{5}}{\cancel{5} \times \underset{2}{\cancel{6}}} = \frac{1}{2};$$

$$\textit{As } \frac{1}{4} : \frac{2}{3} :: \frac{3}{4};$$

$$\text{hence, } \frac{\cancel{4}}{1} \times \frac{2}{\cancel{3}} \times \frac{\cancel{3}}{\cancel{4}} = \frac{2}{1} = £2, \textit{ Answer.}$$

(20*th.*) If 1 *lb.* of cochineal cost £1-5*s.*, what will $36\frac{7}{10}$ *lb.* come to?

$$£1\text{-}5s. = \frac{1 \times 20 + 5}{1 \times 20} = \frac{25}{20} = \frac{5}{4};$$

$$36\tfrac{7}{10} = \frac{367}{10}, \text{ (by Case II.)};$$

$$As\ \frac{1}{1} : \frac{5}{4} :: \frac{367}{10};$$

$$\text{hence, } \frac{1}{1} \times \frac{\cancel{5}}{4} \times \frac{367}{\underset{2}{\cancel{10}}} = \frac{367}{8} = 45\tfrac{7}{8}$$

= £45. 17*s.* 6*d.*, *Answer.*

(21*st.*) If 1 yard of broad-cloth cost $15\frac{5}{8}$*s.*, what will 4 pieces cost, each containing $27\frac{3}{7}$ yards?

$$\text{(By Case II.) } 15\tfrac{5}{8}s. = \frac{125}{8};\ 27\tfrac{3}{7} = \frac{192}{7} \times 4 = \frac{768}{7};$$

$$As\ \frac{1}{1} : \frac{125}{8} :: \frac{768}{7};$$

$$\text{hence, } \frac{1}{1} \times \frac{125}{\cancel{8}} \times \frac{\overset{96}{\cancel{768}}}{7} = \frac{12000}{7} = 1714\tfrac{2}{7}$$

= £85. 14*s.* 3*d.*, $1\frac{5}{7}$*qr.*, *Answer.*

(22*nd*). Bought $3\frac{1}{2}$ pieces of silk, each containing $24\frac{3}{8}$ ells, at 6*s.* $\frac{3}{4}$*d.* per ell, I desire to know what the whole quantity will cost.

$$3\tfrac{1}{2} = \frac{7}{2}, \text{ (by Case II.)};\ \frac{7}{2} \times \frac{195}{8} = \frac{1365}{16};$$

$$24\tfrac{3}{8} = \frac{195}{8} \text{ (by Case II.)};\ 6s.\ \tfrac{3}{4}d. = 6\,\frac{3}{12 \times 4}$$

$$= 6\frac{3}{48} = 6\frac{1}{16} = \frac{97}{16}s., \text{ (by Case II.)};$$

$$As\ \frac{1}{1} : \frac{97}{16} :: \frac{1365}{16};$$

$$\text{hence, } \frac{1}{1} \times \frac{97}{16} \times \frac{1365}{16} = \frac{132405}{256} = 517s.\ 2d.\ 1\tfrac{15}{16}qr.;$$

or, £25. 17*s.* 2*d.* $1\frac{15}{16}$*qr.*, *Answer.*

(23*rd.*) If $25\frac{2}{7}$*s.* will pay for the carriage of 1 *cwt.* $145\frac{1}{4}$ miles, how far may $6\frac{1}{2}$ *cwt.* be carried for the same money?

$145\frac{1}{4} = \frac{581}{4}$, (*by Case II.*);

$$\textit{As } \frac{1}{1} : \frac{581}{4} :: \frac{13}{2};$$

$$\text{hence, } \frac{1}{1} \times \frac{581}{\underset{2}{\cancel{4}}} \times \frac{\cancel{2}}{13} = \frac{581}{26}$$

$= 22\frac{9}{26}$ *m.*, *Answer.*

(24*th.*) If $3\frac{1}{4}$ yards of cloth that is $1\frac{1}{5}$ *yd.* wide be sufficient to make a cloak, how much must I have of that sort which is $\frac{4}{5}$ *yd.* wide to make another of the same size?

(*By Case II.*) $3\frac{1}{4} = \frac{13}{4}$; $1\frac{1}{5} = \frac{6}{5}$;

$$\textit{As } \frac{6}{5} : \frac{13}{4} :: \frac{4}{5};$$

$$\text{hence, } \frac{\overset{3}{\cancel{6}}}{\cancel{5}} \times \frac{13}{\underset{2}{\cancel{4}}} \times \frac{\cancel{5}}{4} = \frac{39}{8} = 4\tfrac{7}{8} \textit{ yds., Answer.}$$

(25*th.*) If a penny loaf weighs 7 *oz.* when a bushel of wheat costs 5*s.* 6*d*, what is a bushel worth when a penny white loaf weighs but $2\frac{1}{2}$ *oz.*?

$5s.\ 6d. = 5\frac{6}{12}$ or $5\frac{1}{2} = \frac{11}{2}$;

$2\frac{1}{2} = \frac{5}{2}$ (*by Case II.*,);

$$\textit{As } \frac{7}{1} : \frac{11}{2} :: \frac{5}{2};$$

$$\text{hence, } \frac{7}{1} \times \frac{11}{\cancel{2}} \times \frac{\cancel{2}}{5} = \frac{77}{5} s.;$$

$= 15$*s.* $4\frac{4}{5}$*d.*, *Answer.*

THE DOUBLE RULE OF THREE IN VULGAR FRACTIONS.

EXAMPLES.

(1*st.*) IF a carrier receives £$2\frac{1}{10}$ for the carriage of 3 *cwt.* 150 miles, how much ought he to receive for the carriage of 7 *cwt.* $3\frac{1}{2}$ *qrs.* 50 miles?

$$2\tfrac{1}{10}=\frac{21}{10},\ (\textit{by Case II.});$$

$$7\ \textit{cwt.},\ 3\tfrac{1}{2}\ \textit{qrs.}=7\,\frac{3\frac{1}{2}\times 2}{4\times 2}=7\tfrac{7}{8}=\frac{63}{8};$$

$$\textit{m.}\ \frac{150}{1}:\frac{21}{10}::\frac{50}{1}\ \textit{m.};\ \text{first, }\frac{150}{1}\times\frac{3}{1}=\frac{450}{1}\ \textit{divisor};$$

$$\textit{cwt.}\ \frac{3}{1}:2::\frac{63}{8}\ \textit{cwt.};\ \text{then, }\frac{\overset{5}{\cancel{50}}}{1}\times\frac{63}{8}\times\frac{21}{\cancel{10}}=\frac{6615}{8}\ \textit{divnd.};$$

$$\text{and, }\frac{6615}{8}\div\frac{450}{1}=\frac{6615}{8}\times\frac{1}{450}=\frac{6615}{300}=1\tfrac{67}{80};$$

or, £1. 16*s.* 9*d.*, *Answer.*

(2*nd.*) If £100 in 12 months gain £6 interest, what principal will gain £$3\frac{3}{8}$ in 9 months?

$$3\tfrac{3}{8}=\frac{27}{8}\ (\textit{by Case II.});$$

$$\overset{\pounds}{\frac{6}{1}}:\overset{\pounds}{\frac{100}{1}}::\overset{\pounds}{\frac{27}{8}},\ \textit{direct};\ \frac{12}{1}:2::\frac{9}{1},\ \textit{inversely};$$

$$\text{first, }\frac{6}{1}\times\frac{9}{1}=\frac{54}{1}\ \textit{divsr.};\ \text{then }\frac{27}{8}\times\frac{12}{1}\times\frac{100}{1}=\frac{32400}{8}\ \textit{divnd.};$$

$$\text{and, }\frac{32400}{8}\div\frac{54}{1}=\frac{600}{8}=\pounds 75,\ \textit{Answer.}$$

(3*rd.*) If 9 students spend £$10\frac{7}{9}$ in 18 days, how much will 20 students spend in 30 days?

$$10\tfrac{7}{9} = \frac{97}{9},\ (\textit{by Case II.});$$

$$\textit{students}\ \frac{9}{1} : \overset{\pounds}{\frac{97}{9}} :: \frac{20}{1}\ \textit{students};\ \textit{days}\ \frac{18}{1} : 2 :: \frac{30}{1}\ \textit{days};$$

$$\text{first, } \frac{9}{1} \times \frac{18}{1} = \frac{162}{1}\ \textit{divisor};\ \text{then, } \frac{20}{1} \times \frac{30}{1} \times \frac{97}{9}$$

$$= \overset{\textit{Dividend.}}{\frac{58200}{9}} \div \frac{162}{1} = \frac{58200}{9} \times \frac{1}{162} = \frac{58200}{1458} = \pounds 39\tfrac{223}{243};$$

or, £39. 18*s.* $4\frac{60}{243}$*d.*, *Answer.*

(**4*th.***) A man and his wife having labored one day earned $4\frac{5}{8}$*s.*, how much must they have for $10\frac{1}{2}$ days when their two sons helped them?

$$4\tfrac{5}{8} = \frac{37}{8}\ (\textit{by Case II.},)\ 10\tfrac{1}{2}\ \frac{21}{2};$$

$$\textit{day}\ \frac{1}{1} : \frac{37}{8} :: \frac{21}{2}$$

$$\frac{2}{1} : 2 :: \frac{4}{1}\,\textit{father, mother, and sons};$$

$$\text{first, } \frac{1}{1} \times \frac{2}{1} = \frac{2}{1}\ \textit{divsr.};\ \text{then, } \frac{21}{2} \times \frac{\overset{2}{\cancel{4}}}{2} \times \frac{37}{\underset{2}{\cancel{8}}} = \frac{1554}{8}\ \textit{divnd.};$$

$$\text{and, } \frac{1554}{8} \div \frac{2}{1} = \frac{777}{8} = 97\tfrac{1}{8} = \pounds 4.\ 17s.\ 1\tfrac{1}{2}d.,\ \textit{Answer.}$$

(5*th.*) If £50 in 5 months gain £$2\frac{37}{144}$, what time will £$13\frac{1}{3}$ require to gain £$1\frac{1}{12}$?

$$(\textit{By Case II.})\ 2\tfrac{37}{144} = \frac{325}{144};\quad 13\tfrac{1}{3} = \frac{40}{3};\quad 1\tfrac{1}{12} = \frac{13}{12};$$

$$\overset{£}{\frac{325}{144}} : \overset{m.}{\frac{5}{1}} :: \overset{£}{\frac{13}{2}}\ \textit{direct; } \text{first, } \frac{325}{\underset{72}{\cancel{144}}} \times \frac{\cancel{40}}{3} = \frac{6500}{216}\ \textit{divisor;}$$

$$\frac{50}{1} : 2 :: \frac{40}{3}\ \textit{inversely; } \text{then, } \frac{13}{\underset{6}{\cancel{12}}} \times \frac{\overset{25}{\cancel{50}}}{1} \times \frac{5}{1} = \frac{162}{6}\ \textit{divnd.,}$$

$$\text{and, } \frac{1625}{6} \div \frac{6500}{216} = \frac{1625}{6} \times \frac{216}{6500} = \frac{351000}{39000}$$

$$= 9\ \textit{mths., Answer.}$$

(6*th.*) If the carriage of 60 *cwt.* 20 miles cost £$14\frac{1}{2}$, what weight can I have carried 30 miles for $5\frac{7}{16}$£?

$$14\tfrac{1}{2} = \frac{29}{2}\ (\textit{by Case II.,});\quad 5\tfrac{7}{16} = \frac{87}{16}\ (\textit{by Case II.});$$

$$\overset{£}{\frac{29}{2}} : \overset{cwt.}{\frac{60}{1}} :: \overset{£}{\frac{87}{16}} \qquad \text{first, } \frac{29}{\cancel{2}} \times \frac{\overset{15}{\cancel{30}}}{1} = \frac{435}{1}\ \textit{divisor;}$$

$$m.\ \frac{20}{1} : 2 :: \frac{30}{1}\ m.,\ \textit{invly.; } \text{then, } \frac{87}{\underset{8}{\cancel{16}}} \times \frac{20}{1} \times \frac{\overset{30}{\cancel{60}}}{1} = \frac{52200}{8}\ \textit{divnd.}$$

$$\text{and, } \frac{52200}{8} \div \frac{435}{1} = \frac{52200}{8} \times \frac{1}{435} = \frac{52200}{3480}$$

$$= 15\ \textit{cwt., Answer.}$$

DECIMAL FRACTIONS.

A Decimal Fraction is that which has for its Denominator an unit (1), with as many ciphers annexed as the Numerator has places; and it is usually expressed by setting down the Numerator only, with a point before it, on the left hand, thus:—

$\frac{4}{10}$ is ·4; $\frac{24}{100}$ is ·24; $\frac{74}{1000}$ is ·074; and $\frac{124}{100000}$ is ·00124,

where ciphers are prefixed to make up as many places as ciphers in the Denominator, when there is a deficiency of figures.

A Mixed Number is made up of a Whole Number with some Decimal Fraction, the one being separated from the other by a point, thus:—

3·25 is the same as $3\frac{25}{100}$ or $\frac{325}{100}$.

Ciphers on the right hand of decimals make no alteration in their value; for ·4, or ·40, or ·400 are decimals having all the same value, each being $=\frac{4}{10}$, or $\frac{2}{5}$; but when they are placed on the left hand they decrease the value in a ten-fold proportion, thus:—

·4 is $\frac{4}{10}$, or 4-tenths; but ·04 is only $\frac{4}{100}$, or 4-hundredths; and ·004 is only $\frac{4}{1000}$, or 4-thousandths.

The first place of decimals, counted from the left hand towards the right, is called the place of *primes* or 10*ths;* the second is the place of *seconds*, or 100*ths;* and the third is the place of *thirds*, or 1000*ths;* and so on. For in Decimals, as well as in Whole Numbers, the values of the places increase towards the left hand, and decrease towards the right, both in the same ten-fold proportion, as in the following scale or table of Notation:—

Millions.	Hundred-thousands.	Ten-thousands.	Thousands.	Hundreds.	Tens.	Units.						
3	3	3	3	3	3	3	3	3	3	3	3	3
						Units.	Tenth parts.	Hundredth parts.	Thousandth parts.	Ten-thousandth parts.	Hundred-thousandth parts.	Millionth parts.

ADDITION OF DECIMALS.

Set the numbers under each other according to the value of their places, like as in Whole Numbers, in which state the decimal separating points will stand all exactly under each other; then, beginning at the right hand, add up all the columns of numbers, as in integers; and point off as many places for Decimals as are in the greatest number of decimal places in any of the lines that are added, or place the point directly below all other points.

EXAMPLES.

(*1st.*) What is the sum of 276, 39·213, 72014·9, 417, and 5032 ?

276·
39·213
72014·9
417·
5032·

77779·113 *the sum.*

(*2nd.*) What is the sum of 7530, 16·201, 3·0142, 957·13, 6·72119, and ·03014 ?

7530·
16·201
3·0142
957·13
6·72119
·03014

8513·09653 *the sum.*

(*3rd.*) What is the sum of 312·09, 3·5711, 7195·6, 71·498, 9739·215, 179, and ·0027 ?

312·09
3·5711
7915·6
71·498
9739·215
179·
·0027

17500·9768 *the sum.*

SUBTRACTION OF DECIMALS.

PLACE the numbers under each other, according to the value of their places, as in the last Rule; then, beginning at the right hand, subtract as in Whole Numbers, and point off the decimals as in Addition.

EXAMPLES.

(*1st.*) Find the difference between 1·9185 and 2·73.

2·73
1·9185

0·8115 *Answer.*

(*2nd.*) To subtract 4·90142 from 214·81.

214·81
4·90142

209·90858 *Answer.*

(*3rd.*) Find the difference between 2714 and ·916.

2714.
·916

2713·084 *Answer.*

MULTIPLICATION OF DECIMALS.

Place the factors, and multiply them together the same as if they were Whole Numbers; then point off in the product just as many places of decimals as there are decimals in both factors; but if there be not so many figures in the product, then supply the defect by prefixing ciphers.

Examples.

(1*st.*) Multiply 49·46 by ·34.

49·46
·34
19784
14838
16·8164 *Answer.*

(2*nd.*) Multiply 79·347 by 23·15.

79·347
23·15
396735
79347
238041
158694
1836·88305 *Answer.*

(3*rd.*) Multiply ·63478 by ·8204.

·63478
·8204
253912
126956
507824
·520773512 *Answer.*

(4*th.*) Multiply ·385746 by ·00464.

·385746
·00464
1542984
2314476
1542984
·00178986144 *Answer.*

CONTRACTION I.

To multiply Decimals by 1 *with any number of ciphers, as by* 10, *or* 100, *or* 1000, *&c.*

This is done by only removing the decimal point so many places further to the right hand as there are ciphers in the Multiplier, and subjoining ciphers if need be.

Examples.

(1*st.*) The product of 2·714 and 100 is 271·4 *Answer.*

(2*nd.*) The product of ·916 and 1000 is 916· *Answer.*

(3*rd.*) The product of 21·31 and 10000 is 213100· *Answer.*

CONTRACTION II.

To contract the operation so as to retain only as many Decimals in the product as may be thought necessary when the product would naturally contain several more places.

Set the unit's place of the Multiplier under the figure of the Multiplicand whose place is the same as is to be retained for the last in the product; and dispose of the rest of the figures in the inverted or contrary order to what they are usually placed in: then, in multiplying, reject all the figures that are more to the right hand than each multiplying figure, and set down the products, so that their right hand figures may fall in a column straight below each other, but observing to increase the first figure of every line with what would arise from the figures omitted, in this manner, namely,—1 *from* 5 *to* 14, 2 *from* 15 *to* 24, 3 *from* 25 *to* 34, &c., and the sum of all the lines will be the product as required, commonly to the nearest unit in the last figure.

EXAMPLES.

(1*st.*) Multiply 480·14936 by 2·72416, retaining only four decimals in the product.

```
480·14936
 614272
---------
 9602987
 3361045
   96030
   19206
     480
     288
---------
1308·0036 Answer.
```

(2*nd.*) Multiply 2490·3048 by ·573286, retaining only five decimals in the product.

```
 2590·3048
   682375
----------
 124515240
  17432184
    747091
     49806
     19922
      1494
----------
1427 65687 Answer.
```

(3*rd.*) Multiply 325·701428 by ·7218393, retaining only three decimals in the product.

325·701428
3938127·

227991
6514
326
261
10
2

235·104 *Answer.*

(4*th.*) Multiply 3·141592 by 52·7438, retaining only four decimals in the product.

3·141592
834725

1570796
62832
21991
1257
94
25

165·6995 *Answer.*

(5*th.*) Multiply 2·38645 by 82175, retaining only four decimals in the product.

2·38645
57128

190916
4773
239
167
12

19·6107 *Answer.*

(6*th.*) Multiply 375·13758 by 16·7324, retaining only four places of decimals.

375·13758
423761

37514
22508
2626
113
7
1

6276·9 *Answer.*

(7*th.*) Multiply 395·3756 by 75642, retaining only four decimals in the product.

395·3756
24657

2767629
197688
23722
1581
79

299·0699 *Answer.*

DIVISION OF DECIMALS.

Divide as in Whole numbers; and point off in the quotient as many places for decimals as the decimal places in the Dividend exceed those in the Divisor.

Another way to know the place for the decimal point is this:—The first figure of the quotient must be made to occupy the same place of integers or decimals, as doth that figure of the Dividend which stands over the unit's figure of the first product.

When places of the quotient are not so many as the Rule requires, the defect is to be supplied by prefixing ciphers.

When there happens to be a Remainder after the division, or when the decimal places in the Divisor are more than those in the Dividend, then ciphers may be annexed to the Dividend, and the quotient carried on as far as required.

Examples.

(1*st.*) Divide 123·70536 by 54·25.

54·25|123·70536|2·28028 + *Ans.*
10850
———
15205
10850
———
43553
43400
———
15360
10850
———
45100
43400
———
1700

(2*nd.*) Divide 12 by ·7854.

·7854|12·0000|15·278838 + *Ans.*
7854
———
41460
39270
———
21900
15708
———
61920
54978
———
69420
62832
———
65880
62832
———
30480
23562
———
69180
62832
———
6348

(3*rd*.) Divide ·8297592 by ·153.

```
·153|·8297592|5·42326 + Ans.
     765
     ———
      647
      612
      ———
       355
       306
       ———
        499
        459
        ———
         402
         306
         ———
          960
          918
          ———
           42
```

(4*th*.) Divide 48 by 144.

```
      ⎧  12|48
  144 ⎨   12|4
      ⎩      ————
             0·333 + Ans.
```

(5*th*.) Divide 217·75 by 65.

```
65|217·75|3·35 Ans.
   195
   ———
    227
    195
    ———
     325
     325
     ———
     . . .
```

(6*th*.) Divide 125 by ·1045.

```
·1045|125·0000|1196·1722+Ans.
      1045
      ————
       2050
       1045
       ————
       10050
        9405
        —————
         6450
         6270
         ————
          1800
          1045
          ————
           7550
           7315
           ————
            2350
            2090
            ————
             2600
             2090
             ————
              510
```

(7*th*.) Divide 709 by 2·574.

```
2·574|709·000|275·4467 + Ans.
      5148
      —————
      19420
      18018
      —————
       14020
       12870
       —————
        11500
        10296
        —————
         12040
         10296
         —————
          17440
          15444
          —————
           19960
           18018
           —————
```

(8*th.*) Divide 5·714 by 8275.

8275|5·7140|·0006905135 +
49650 [*Ans.*
74900
74475
42500
41375
11250
8275
29750
24825
49250
41375
7875

(9*th.*) Divide 7282·54 by 6·4252.

6·4252|7382·5400|1148·9976+
64252 [*Ans.*
95734
64252
314820
257008
578120
514016
641040
578268
627720
578268
494520
449764
447560
385512
62048

(10*th.*) Divide ·0851648 by 423.

423|·0851648| ·00020133522 +
846 [*Ans.*
564
423
1418
1269
1490
1269
2210
2115
950
846
1040
846
194

(11*th.*) Divide 267·15975 by 13·25.

13·25|267·15975|20·163 + *Ans.*
2650
2159
1325
8347
7950
3975
3975
. . .

(12*th.*) Divide 72·1564 by ·1347.

·1347|72·156400|535·6822 + [*Ans.*
6735
4806
4041
7654
6735
9190
8082
11080
10776
3040
2694
3460
2694
766

(13*th.*) Divide 715 by ·3075.

·3075|715·0000|2325·203 + *Ans.*
6150
10000
9225
7750
6150
16000
15375
6250
6150
10000
9225
775

CONTRACTION I.

When the Divisor is an integer, with any number of ciphers annexed, cut off those ciphers, and remove the decimal point in the Dividend as many places further to the left as there are ciphers cut off, prefixing ciphers if need be; then proceed as before.

EXAMPLES.

(1*st.*) Divide 41020 by 32000.

32,000|41·020|1·281875 *Ans.*
32
90
64
262
256
60
32
280
256
240
224
160
160
. . .

(2*nd.*) Divide 61 by 79000.

79,000|0610|·07721518 *Ans.*
553
570
553
170
158
120
79
410
395
150
79
710
632
78

(*3rd.*) Divide 953 by 21600.

```
216,00|953|·0441412 + Answer.
       864
       ───
        890
        864
        ───
         260
         216
         ───
          440
          432
          ───
            8
```

CONTRACTION II.

Hence if the Divisor be 1, with ciphers as 10, 100, or 1000, &c., then the quotient will be found by merely moving the decimal point in the Dividend so many places further to the left as the Divisor has ciphers, prefixing ciphers if there be need.

EXAMPLES.

(1*st.*) 5·16 ÷ 100 = ·0516, *Answer.*
(2*nd.*) 419 ÷ 10 = 41·9, *Answer.*
(3*rd.*) ·21 ÷ 1000 = ·00021, *Answer.*

CONTRACTION III.

When there are many figures in the Divisor, or when only a certain number of decimals are necessary to be retained in the quotient, than take only as many figures of the Divisor as will be equal to the number of figures, both integers and decimals, to be in the quotient, and find how many times they may be contained in the first figures of the Dividend as usual.

Let each Remainder be a new Dividend, and for every such Dividend leave out one figure more on the right hand side of the Divisor, remembering to carry for the increase of the figures cut off, as in the second Contraction in Multiplication.

NOTE.—When there are not so many figures in the Divisor as are required to be in the Quotient, begin the operation with all the figures, and continue it as usual, till the number of figures in the Divisor be equal to those remaining to be found in the Quotient, after which begin the contraction.

EXAMPLES.

(1*st*.) Divide 4109·2351 by 230·409, so that the quotient may contain only four decimals.

230·409|4109·2351|17·8345 *Answer.*

230409
180514
161286
19228
18433
795
691
104
92
12
12
. .

(2*nd*.) Divide 37·10438 by 5713·96, that the quotient may contain only five decimals.

5713·96|37·10438|·00649 *Ans.*

3428
282
229
53
51
2

(3*rd*.) Divide 913·08 by 2137·2, that the quotient may contain only three decimals.

2137·2|913·08|·427 *Answer.*

855
58
43
15
15
. .

(4*th*.) Divide 8·7586150 by 5·2714167, that the quotient may contain only three decimals.

5·2714167|8·7586150|1·661 *Ans.*

5271
3487
3163
324
316
8
5
3

(5*th.*) Divide 25·1367 by 217·35, so that the quotient may contain only three decimals.

```
217·35|25136·7|·115 Ans.
         217
         ---
          34
          22
          --
          12
          11
          --
           1
```

(6*th.*) Divide 51·47542 by ·123415, so that the quotient may contain only three decimals.

```
·123415|51·47542|41·709 Ans.
         49366
         -----
          2109
          1234
          ----
           875
           864
           ---
            11
            11
            --
            ..
```

(7*th.*) Divide 51717591 by 8·7586, so that the quotient may contain only three decimals.

```
8·7586|51717591·0000|5904778·275 Answer.
       437930
       ------
        792459
        788274
        ------
         418510
         350344
         ------
          681660
          613102
          ------
          685580
          613102
---       ------
657        72478
613        70069
---        -----
 44         2409
 44         1752
 --         ----
 ..          657
```

(8*th.*) Divide 70·2300 by 7·9863, so that the quotient may contain only three decimals.

```
7·9863|70·2300|8·7938 Ans.
       638904
       ------
        63396
        55904
        -----
         7492
         7188
         ----
          304
          239
          ---
           65
           62
           --
            3
```

(9*th.*) Divide 27·104 by 3·712, so that the quotient may contain only three decimals.

```
3·712|27·104|7·301 Answer.
      25984
      -----
       1120
       1114
       ----
          6
          4
          -
          2
```

REDUCTION OF DECIMALS.

CASE I.

To reduce a Vulgar Fraction to its equivalent Decimal.

Divide the Numerator by the Denominator, as in Division of Decimals, annexing ciphers to the Numerator as far as necessary, so shall the quotient be the Decimal required.

Examples.

(1*st.*) Reduce $\frac{5}{26}$ to decimals.

$$26\left\{\begin{array}{r|l} 2 & 5\cdot0 \\ \hline 13 & 2\cdot5000000 \\ \hline & \cdot1923076 + \end{array}\right.$$

Answer.

(2*nd.*) Reduce $\frac{1}{4}$ and $\frac{1}{2}$ and $\frac{3}{4}$ to decimals.

$$\begin{array}{r|l} 4 & 1\cdot00 \\ \hline & \cdot25 \end{array} \qquad \begin{array}{r|l} 2 & 1\cdot0 \\ \hline & \cdot5 \end{array} \qquad \begin{array}{r|l} 4 & 3\cdot00 \\ \hline & \cdot75 \end{array}$$

(3*rd.*) Reduce $\frac{5}{8}$ to a decimal.

$$\begin{array}{r|l} 8 & 5\cdot000 \\ \hline & \cdot625 \end{array}$$

Answer.

(4*th.*) Reduce $\frac{3}{25}$ to a decimal.

$$25\left\{\begin{array}{r|l} 5 & 3\cdot0 \\ \hline 5 & \cdot60 \\ \hline & \cdot12 \end{array}\right.$$

Answer.

(5*th.*) Reduce $\frac{550}{3842}$ to a decimal.

$$3842|550\cdot0|\cdot143154 +$$

Ans.

$$\begin{array}{r} 3842 \\ \hline 16580 \\ 15368 \\ \hline 12120 \\ 11526 \\ \hline 5940 \\ 3842 \\ \hline 20980 \\ 19210 \\ \hline 17700 \\ 15368 \\ \hline 2332 \end{array}$$

(6*th.*) Reduce $\frac{6}{192}$ to a decimal.

$$192\left\{\begin{array}{r|l} 16 & 6\cdot000 \\ \hline 12 & \cdot37500 \\ \hline & \cdot03125 \end{array}\right.$$

Answer.

(7*th.*) Reduce $\frac{11}{14}$ *of* $\frac{10}{13}$ to a decimal.

$$\frac{11}{\underset{7}{\cancel{14}}} \text{ of } \frac{\overset{5}{\cancel{10}}}{13} = \frac{55}{91};$$

$$91\left\{\begin{array}{r|l} 7 & 55\cdot0000000 \\ \hline 13 & 7\cdot8571428 + \\ \hline & \cdot6043956 + \end{array}\right.$$

Ans.

(8*th.*) Reduce $\frac{3}{8}$ to a decimal.

$$\begin{array}{r|l} 8 & 3\cdot000 \\ \hline & \cdot375 \end{array}$$

Answer.

(9*th.*) Reduce $\frac{9}{18}$ to a decimal.

$$18\left\{\begin{array}{r|l} 6 & 9\cdot0 \\ \hline 3 & 1\cdot5 \\ \hline & \cdot5 \end{array}\right.$$

Answer.

CASE II.

To find the Value of a Decimal in terms of the inferior Denominations.

Multiply the Decimal by the number of parts in the next lower denomination, and cut off as many places as the given Decimal; multiply that Remainder by the parts in the next lower denomination again, cutting off for another Remainder as before.

Proceed in the same manner through all the parts of the Integer; then the several denominations separated on the left hand will make up the answer.

Note.—This operation is the same as Reduction *descending.*

EXAMPLES.

(1*st.*) What is the value of ·625 shilling?

·625
12
d. 7·500
4
2·000

7½*d.*, *Answer.*

(2*nd*) What is the value of 8·635 £?

8·635
20
17·2700
12
3·2400

17*s.* 3·24*d.*, *Answer.*

(3*rd.*) What is the value of ·0125 *lb.*, Troy?

·0125
12
·1500
20
dwts., 3·0000

3 *dwts.*, *Answer.*

(4*th.*) What is the value of ·4694 *lb.*, Troy?

4694
12
5·6328 *oz.*
20
12·6560 *dwts.*
24
26240
13120
15·7440 *grs.*

5*oz.* 12 *dwts.* 15,744 *grs.*, *Answer.*

(5*th.*) What is the value of ·625 *cwt.*?

·625
4
2·500 *qrs.*
28
14·000 *lbs.*

2 *qrs.* 14 *lbs.*, *Answer.*

(6*th.*) What is the value of ·009943 miles?

·009943
1760 *yds.*
0596580
69601
9943
yds. 17·499680
3
1·499040
12
5·988480

17 *yds.* 1 *ft.* 5·98848 *in.*, *Answer.*

(7*th.*) What is the value of ·6875 *yds.* ?

·6875
4
2·7500
4
3·0000

2 *qrs.* 3 *nls.*, *Answer.*

(8*th.*) What is the value of ·3375 acre?

·3375
4
1·3500
40
14·0000

1 *rd.* 14 *pls.*, *Answer.*

(9*th.*) What is the value of ·2083 *hhds.* of wine?

·2083
63
6249
12498
13·1229

13·1229 *gals.*, *Answer.*

CASE III.

To reduce Integers or Decimals to equivalent Decimals of higher Denominations.

Divide by the number of parts in the next higher denomination, continuing the operation to as many higher denominations as may be necessary, the same as in Reduction *ascending* of Whole Numbers.

Examples.

(1*st.*) Reduce 9*d.* to the decimal of a pound.

12|9· *d.*
20|0·75 *s.*
0·0375 £

(2*nd.*) Reduce 7 drams to the decimal of a pound Avoirdupois.

16|7· *drs.*
16|0·4375
0·02734375 *lb.*

(*3rd.*) Reduce ·26*d.* to the decimal of a £.

$$\begin{array}{r|l} 12 & \cdot 26\ d. \\ 20 & \cdot 0216666 \\ & \cdot 0010833 + \pounds. \end{array}$$

(*4th.*) Reduce 2·15 *lb.* to the decimal of a *cwt.*

$$28\left\{\begin{array}{r|l} 7 & 2{\cdot}15 \\ 4 & 0{\cdot}307142 + \\ 4 & 0{\cdot}076785 + \ qr. \\ & 0{\cdot}019196 + \ cwt. \end{array}\right.$$

(*5th.*) Reduce 24 *yds.* to the decimal of a mile.

$$1760\left\{\begin{array}{r|l} 110 & 24\cdot\ yds. \\ 16 & \cdot 218181 + \\ & \cdot 013636 + \ ms. \end{array}\right.$$

(*6th.*) Reduce ·056 pole to the decimal of an acre.

$$\begin{array}{r|l} 40 & \cdot 056\ pl. \\ 4 & \cdot 0014\ rd. \\ & \cdot 0035\ ac. \end{array}$$

(*7th.*) Reduce 1·2 pints of wine to the decimal of a *hhd.*

$$\begin{array}{r|l} 8 & 1{\cdot}2 \\ 9 & 0{\cdot}15 \\ 7 & 0{\cdot}01666 + \\ & 0{\cdot}00238 + \ hhd. \end{array}$$

(*8th.*) Reduce 14 minutes to the decimal of a day.

$$\begin{array}{r|l} 60 & 14\cdot \end{array}$$

$$24\left\{\begin{array}{r|l} 3 & 0{\cdot}233333 + \\ 8 & 0{\cdot}077777 + \\ & 0{\cdot}009722 + \end{array}\right.$$

(*9th.*) Reduce ·21 pints to the decimal of a peck.

$$\begin{array}{r|l} 16 & \cdot 21\ pts. \\ & \cdot 013125\ pk. \end{array}$$

(*10th.*) Reduce 28″ 12‴ to the decimal of a minute.

$$\begin{array}{r|l} & 28''\ 12''' \\ & 60 \\ 60 & 1692''' \\ 60 & 28{\cdot}2 \\ & \cdot 47\ min. \end{array} \quad \text{or,} \quad \begin{array}{r|l} 60 & 12''' \\ 60 & 28{\cdot}2 \\ & \cdot 47\ min. \end{array}$$

Note.—When there are several numbers to be reduced all to the Decimal of the highest, set the given numbers directly under each other for Dividends, proceeding orderly from the lowest denomination to the highest.

Opposite to each Dividend, on the left hand, set such a number for a Divisor as will bring it to the higher name,—drawing a perpendicular line between all the Divisors and Dividends.

Begin at the uppermost, and perform all the divisions, only observing to set the Quotient of each division as Decimal parts on the right hand of the Dividend next below it,—so shall the last Quotient be the Decimal required.

EXAMPLES.

(1*st.*) Reduce £19. 17*s.* 3¼*d.* to £.

4	1·
12	3·25 *d.*
20	17·2708333 *&c.*
	19·86354166 *&c.*

(2*nd.*) Reduce 15*s.* 6*d.* to the decimal of a £.

12	6·
20	15·5
	·775 £.

(3*rd.*) Reduce 7½*d.* to the decimal of a shilling.

4	2·
12	7·5
	·625*s.*

(4*th.*) Reduce 5 *oz.* 12 *dwts.* 16 *grs.* to a *lb.*

24	16·
20	12·66666 *&c.*
12	5·63333 *&c.*
	·46944 *lb.*, *&c.*

(5*th.*) Reduce 19*s.* 5½*d.* to the decimal of a £.

4	2·
12	5·5
20	19·458333 *&c.*
	·972916 £.

(6*th.*) Reduce 12 grains to the decimal of a *lb.* Troy.

24	12
20	·5
12	·025
	·002083 *&c.*

CIRCULATING DECIMALS.

It has already been observed, that when an infinite Decimal repeats always one figure, it is a Repetend; and when more than one, a Compound Repetend, or a Circulate; also that a point is set over a single Repetend, and a point over the first and last figures of a Circulate.

It may further be observed, that when other decimal figures precede a Repetend in any numbers, it is called a Mixed Number or quantity, as $\cdot 2\dot{3}$ or $\cdot 104\dot{1}2\dot{3}$,—otherwise it is a pure Repetend, as $\cdot\dot{3}$ and $\cdot\dot{1}2\dot{3}$.

Similar Repetends begin at the same place, and consist of the same number of figures; as $\cdot\dot{3}$ and $\cdot\dot{6}$, or $1\cdot\dot{3}4\dot{1}$ and $2\cdot\dot{1}5\dot{6}$.

Dissimilar Repetends begin at different and consist of unequal number of figures.

Similar and conterminous Repetends begin and end at the same place; as $2\cdot 9\dot{1}0\dot{4}$ and $\cdot 0\dot{6}1\dot{3}$.

REDUCTION OF REPEATING DECIMALS.

CASE I.

To reduce a single Repetend to a Vulgar Fraction.

Make the given Decimal the Numerator, and for a Denominator take as many *nines* as there are recurring places in the given Repetend.

If one or more on the left hand places in the given Decimal be ciphers, annex as many ciphers to the right hand of the *nines* in the Denominator.

Examples.

(1*st.*) Reduce ·3 to a vulgar fraction.

$$\cdot\dot{3} = \frac{3}{9} = \tfrac{1}{3}, \text{ Answer.}$$

(2*nd.*) Reduce $\cdot\dot{6}$ to a vulgar fraction.

$$\cdot\dot{6} = \frac{6}{9} = \tfrac{2}{3}, \text{ Answer.}$$

(3*rd.*) Reduce $\cdot0\dot{6}$ to a vulgar fraction.

$$\cdot0\dot{6} = \frac{6}{90} = \frac{1}{15}, \textit{ Ans.}$$

(4*th.*) Reduce $\cdot\dot{1}2\dot{3}$ to a vulgar fraction.

$$\cdot\dot{1}2\dot{3} = \frac{123}{999} = \frac{41}{333}, \textit{ Ans.}$$

(5*th.*) Reduce $\cdot\dot{7}0\dot{2}$ to a vulgar fraction.

$$\cdot\dot{7}0\dot{2} = \frac{702}{999} = \frac{26}{37}, \textit{ Ans.}$$

(6*th.*) Reduce $\cdot\dot{3}4\dot{2}$ to a vulgar fraction.

$$\cdot\dot{3}4\dot{2} = \frac{342}{999} = \frac{38}{111}, \textit{ Ans.}$$

CASE II.

To reduce a mixed Repetend to a Vulgar Fraction.

To as many *nines* as there are figures in the Repetend annex as many ciphers as there are finite places for the Denominator of the Vulgar Fraction.

Multiply the *nines* in the Denominator by the finite part of the Decimal, and to the product add the repeating part for the Numerator.

Or, find the Vulgar Fraction as before answering to the Repetend, then join it to the finite part, and reduce them to a Common Denominator.

EXAMPLES.

(1*st.*) Reduce $\cdot16\dot{3}$ to a vulgar fraction.

$$\frac{9 \times 16 + 3}{900} = \frac{147}{900} = \frac{49}{300}$$

[*Ans.*

(2*nd.*) Reduce $\cdot84\dot{6}$ to a vulgar fraction.

$$\frac{9 \times 84 + 6}{900} = \frac{762}{900} = \frac{127}{150}$$

(3*rd.*) Reduce $04\dot{1}2\dot{1}$ to a vulgar fraction.

$$\frac{999 \times 4 + 121}{99900} = \frac{4117}{99900}$$

[*Ans.*

(4*th.*) Reduce $7\cdot4363$ to a vulgar fraction.

$$\frac{99 \times 43 + 63}{9900} = 7\,\frac{4320}{9900} = 7\tfrac{24}{55}$$

(*5th.*) Reduce $\cdot 50\dot{6}8\dot{5}$ to a vulgar fraction.

$$\frac{999 \times 50 + 685}{99900} = \frac{50635}{99900} = \frac{10127}{19980}, \textit{ Answer.}$$

(*6th.*) Reduce $\cdot 2\dot{5}672\dot{1}$ to a vulgar fraction.

$$\frac{99999 \times 2 + 56721}{999990} = \frac{256719}{999990} = \frac{85573}{333330}, \textit{ Answer.}$$

THE RULE OF THREE IN DECIMALS.

PREPARE the Terms, by reducing the Vulgar Fractions to Decimals, and any Compound Numbers either to Decimals of the higher denominations or to Integers of the lower, also the first and third Terms to the same name; then multiply and divide, as in Whole Numbers.

NOTE.—Any of the convenient examples in the Rule of Three or Rule of Five, in Integers or Vulgar Fractions, may be taken as proper examples to the same Rules in Decimals.

EXAMPLES.

(*1st.*) What will the pay of 540 men come to at £1 5*s.* 6*d.* per man?

$$\begin{array}{lrrr} & \textit{man.} & \pounds & \textit{men.} \\ \textit{As} & 1 : & 1{\cdot}275 :: & 540 \\ & & 540 & \\ \hline & & 51000 & \\ & & 6375 & \\ \hline & & 688{\cdot}5 ; & \text{or, } \pounds 688\ 10s., \textit{ Answer.} \end{array}$$

(2*nd.*) If 7¾ *yds.* of cloth cost £2 12*s.* 9*d.*, what will 140½ *yds.* of the same cost?

```
     yds.       £.         yds.
As 7·75  :  2·6735  : :  140·5
              140·5
            -------
            13·1875
          105500
          26375
      ------------
 7·75|370·56875|£47·815
      3100
      ----
       6056
       5425
       ----
        6318
        6200
        ----
         1187
          775
         ----
          4125
          3875
          ----
           250
```

£47 - 16*s.* 3*d.*, 2·4*qr.*, *Answer.*

(3*rd.*) If a chest of sugar weighing 7 *cwt.* 2 *qrs.* 14 *lbs.*, cost £ 36 12*s.* 9*d.*, what will 2 *cwt.* 1 *qr.* 21 *lbs.* of the same cost?

```
     cwts.        £           cwts.
As 7·625  :  36·6375  : :  2·4375
                2·4375
              --------
              1831875
             2564625
            1099125
           1465500
           732750                  [nearly.
        ----------
 7·625|89·30390625|£11·712
         7625                  20
        -----               -----
        13053               14·24
         7625                  12
         ----               -----
          5428               2·88
          5338                  4
          ----               ----
            90               3·52
            76
            --
            14
```

£11 - 14*s.* 2·35 *qr.*, *Answer.*

(4*th.*) A grocer buys 24 *tns.* 12 *cwt.* 2 *qrs.* 14 *lbs.* 12 *oz.* of tobacco for £3,678 - 6*s.* 4*d.*, what will 1 *oz.* come to?

```
As 24·63154 : 3678·3166 : : ·0000279
                ·0000279
              ----------
               331048494
              257482162
              73566362
           -------------
 24·631584|·10262503314|·004166
             98526336          20
             --------   ---------
              4098697    0·08332
              2463158         12
              -------    -------
              1635539     ·99984
              1477895          4
              -------    -------
               157644    ¾99936
               147790
               ------
                 9854     1 d., nearly, Answer.
```

(*5th.*) What is the worth of 19 *oz.* 3 *dwts.* 5 *grs.* of gold, at £2 - 19*s.* per *oz.*?

As $\overset{\text{oz.}}{1} : \overset{\pounds}{2{\cdot}95} : : \overset{\text{oz.}}{19{\cdot}1604}$
2·95
958020
1724436
383208
56·52318·
20
10·4636· ·
12
5·5632· ·
4
2·2528· ·

£56 - 10*s.* 5½*d.*, *Ans.*

(*6th.*) What is the worth of 827¾ *yds.* of painting, at 10½*d.* per yard?

As $\overset{\text{yd.}}{1} : \overset{\pounds}{{\cdot}04375} : : \overset{\text{yds.}}{827{\cdot}75}$
827·75
21875
30625
30625
8750
35000
36·2140625
20
4·28125 · ·
12
3·375 · · · ·
4
15 · · · · · ·

£36 - 4*s.* 3⅕*d.*, *Ans.*

(*7th.*) If ¾ of a *yd.* of cloth that is 2¼ *yds.* broad make a garment, how much that is ⅘ of a *yd.* wide will make the same?

As $\overset{\text{yds.}}{8} : \overset{\text{yds.}}{2{\cdot}25} : : \overset{\text{yds.}}{{\cdot}75}$
·75
1125
1575
8|16875
2·109375 *yds.*, *Ans.*

(*8th.*) What will 326¼ *lbs.* of tobacco come to, when 1½ *lb.* is sold for 3*s.* 6*d.*?

As $\overset{\text{lb.}}{1{\cdot}5} : \overset{\pounds}{{\cdot}175} : : \overset{\text{lb.}}{326{\cdot}25}$
·175
163125
228375
32625
1·5|57·09375
£38·0625
20
s. 1·25
12
£38 - 1*s.* 3*d.*, *Ans.* *d.* 3·

(*9th.*) If one ounce of silver cost 5*s.* 6*d.*, what is the price of a tankard that weighs 1 *lb.* 10 *oz.* 10 *dwts.* 4 *grs.*?

As $\overset{\text{lb.}}{{\cdot}0833} : \overset{\pounds}{{\cdot}275} : : \overset{\text{lb.}}{1{\cdot}875}$
·275
9375
13125
3750
·0833|·515625|6·19
4998 20
158 3·8
83 12
75 9·6
75 4
£6 - 3*s.* 9½*d.*, *Ans.* ... 2·4

(10*th.*) If 1 *lb.* of tobacco cost 15 *d.*, what cost 3 hogsheads weighing together 15 *cwt.* 1 *qr.* 19 *lbs.* ?

```
          cwt.        £          cwt.
As ·008928·57 : ·0625 : : 15·41964
                             ·0625
                          --------
                           7709820
                          3083928
                         9251784
                        ------------
            ·00892857)·963727500(107·9375
                        892857              20
                        -------         -------
                        7087050           18·75
                        6249999              12
                        -------           -----
                         837051               9·
                         803571
                         ------
                          33480
                          26785
                          -----
                           6695
                           6250
                           ----
                            445
                            445
                            ---
                            ...
```

£ 107 - 18*s.* 9*d.*, *Ans.*

(11*th.*) If 1 *cwt.* of currants cost £ 2 - 9*s.* 6*d.*, what will 45 *cwt.* 3 *qrs.* 14 *lbs.* cost at the same rate?

```
    cwt.   £         cwt.
As   1  : 2·475 : : 45·875
                     2·475
                    ------
                    229375
                   321125
                  183500
                 191750
                ----------
                113·540625
                        20
                ----------
                 10·81250
                        12
                 ---------
                   9·75000
                         4
                   -------
                        3·
```

£113 - 10*s.* 9¾*d.*, *Ans.*

(12*th.*) Bought 6 chests of sugar, each 6 *cwt.* 3 *qrs.*, at £2 - 16*s.* per *cwt.*, what do they come to?

```
    cwt.  £        cwt.
As   1  : 2 8 : : 6·75
                     6
                 -----
                 40·50
                    28
                 -----
                 32400
                 8100
                ------
                113·4
                   20
                   --
                    8·
```

£113 - 8*s.*, *Ans.*

(13*th.*) Gave £187 - 3*s.* 3*d.* for 25 *cwt.* 3 *qrs.* 14 *lbs.* of tobacco, at what rate did I buy it per *lb.*?

```
       cwt.          £             cwt.
   As 25·875  :  187·1625  : :  ·0089285 :
                 ·0089285
                 --------
                  9358125
                14973000
                3743250
              16844625
             14973000
             ------------
  25·875|1·67108038125|·6458
          155250            20
          ------         -----
            118580      1·2916
            103500          12
            ------      ------
             15080      3·4992
             12938           4
             -----      ------
              2142      1·9968
              2070
              ----
                72
```

1*s.* 3½*d.*, nearly, *Answer.*

(14*th.*) Bought 29 *lbs.* 4 *oz.* of coffee for £10-11-3, what is the value of 3 *lbs.*?

```
        lb.       £
   As 29·25  :  10·5625  : :  3lb.
                      3
               -------
               |31·6875|1·0833
                2925        20
                ----     -----
                 24375   1·666
                 23400      12
                 -----   -----
                   975   7·992
                   878
                   ---
                    97
                    88
                    --
                     9
```

£1 - 1*s.* 7*d.*, nearly, *Answer.*

DUODECIMALS.

Duodecimals, or Cross-Multiplication, is a rule used by workmen and artificers in computing the contents of their work.

Dimensions are usually taken in feet, inches, and quarters, any parts smaller than these being neglected as of no consequence, and the same in multiplying them together, or computing the contents. The method is as follows:—

Set down the two dimensions to be multiplied together, one under the other, so that feet may stand under feet, inches under inches, &c. Multiplying each Term in the Multiplicand, begin at the lowest by the feet in the Multiplier, and set the result of each straight under its corresponding Term, observing to carry 1 for every 12 from the inches to the feet.

In like manner, multiply all the Multiplicand by the inches and parts of the Multiplier, and set the result of each term one place removed to the right hand of those in the Multiplicand,—omitting, however, what is below parts of inches, only carrying to these the proper number of units from the lowest denomination. Or, instead of multiplying by the inches, take such parts of the Multiplicand as these are of a foot; then add the two lines together after the manner of Compound Addition, carrying 1 to the feet for 12 inches when these come to so many.

Examples.

(1*st.*) Multiply 4 feet 7 inches by 9 feet 6 inches.

ft. in.
4 - 7
9 - 6
41 - 3
2 - 3 - 6
43 - 6 - 6

(2*nd.*) Multiply 12 feet 5 inches by 6 feet 8 inches.

ft. in.
12 - 5
6 - 8
74 - 6
8 - 3 - 4
82 - 9 - 4

(3*rd.*) Multiply 35 feet 4½ inches by 12 feet 3 inches.

$$\begin{array}{l}
\text{ft.}\ \ {}'\ \ {}''\\
35-4-6\\
12-3\\ \hline
424-6-0\\
8-10-1-6\\ \hline
433-4-1-6
\end{array}$$

(4*th.*) Multiply 64 feet 6 inches by 8 feet 9¼ inches.

$$\begin{array}{l}
\text{ft.}\ \ {}'\\
64-6\\
8-9-3\\ \hline
516-0-0\\
48-4-6\\
1-4-1-6\\ \hline
565-8-7-6
\end{array}$$

(5*th.*) Multiply 4 feet 7′ by 6 feet 4′.

$$\begin{array}{l}
\text{ft.}\ \ {}'\\
4-7\\
6-4\\ \hline
27-6\\
1-6-4\\ \hline
29-0-4
\end{array}$$

(6*th.*) Multiply 14 feet 9′-9″ by 4 feet 6 inches.

$$\begin{array}{l}
\text{ft.}\ \ {}'\ \ {}''\\
14-9-9\\
4-6-0\\ \hline
59-3-0\\
7-4-10-6\\ \hline
66-7-10-6
\end{array}$$

(7*th.*) Multiply 4 feet 7′ 8″ by 9 feet 6′.

$$\begin{array}{l}
\text{ft.}\ \ {}'\ \ {}''\\
4-7-8\\
9-6-0\\ \hline
41-9-0\\
2-3-10\\ \hline
44-0-10
\end{array}$$

(8*th.*) Multiply 7 feet 8′ 6″ by 10 feet 4′-5″.

$$\begin{array}{l}
\text{ft.}\ \ {}'\ \ {}''\\
7-8-6\\
10-4-5\\ \hline
77-1-0\\
2-6-10\\
0-3-2-6-6\\ \hline
79-11-0-6-6
\end{array}$$

(9*th.*) Multiply 39 feet 10′ 7″ by 18 feet 8′ 4″.

$$\begin{array}{l}
\ \ {}'\ \ {}''\\
39-10-7\\
18-8-4\\ \hline
717-10-6\\
26-7-0-8\\
1-1-3-6-4\\ \hline
745-6-10-2-4
\end{array}$$

(10*th.*) Multiply 44 feet 2′ 9″ 2‴ 4 *iv.* by 2 feet 10′ 3″.

$$\begin{array}{l}
\text{f.}\ \ {}'\ \ {}''\ \ {}'''\ \ \text{iv.}\\
44-2-9-2-4\\
2-10-3\\ \hline
88-5-6-4-8\\
36-10-3-7-11-4\\
11-0-8-3-7\\ \hline
126-2-10-8-10-11
\end{array}$$

(11*th.*) Multiply 24 feet 10′ 8″ 7‴ 5 *iv.* by 9 feet 4′ 6″.

$$\begin{array}{l}
\text{ft.}\ \ {}'\ \ {}''\ \ {}'''\ \ \text{iv.}\\
24-10-8-7-5\\
9-4-6\\ \hline
224-0-5-6-9\\
8-3-6-10-5-8\\
1-0-5-4-3-8-6\\ \hline
233-4-5-9-6-4-6
\end{array}$$

INVOLUTION.

INVOLUTION is the raising of powers from any given number, as a root.

A *power* is a quantity produced by multiplying any given number, called the *root*, a certain number of times continually by itself, thus:—

$$2 = 2, \text{ is the root, or 1st power of } 2;$$
$$2 \times 2 = 4, \text{ is the 2nd power, or square of } 2;$$
$$2 \times 2 \times 2 = 8, \text{ is the 3rd power, or cube of } 2;$$
$$2 \times 2 \times 2 \times 2 = 16, \text{ is the 4th power of 2, \&c.}$$

And in this manner may be calculated the following table of the first nine powers of the first six numbers:—

1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*
1	1	1	1	1	1	1	1	1
2	4	8	16	32	64	128	256	512
3	9	27	81	243	729	2187	6561	19683
4	16	64	256	1024	4096	16884	65536	262144
5	25	125	625	3115	15625	78125	390625	1953125
6	36	216	1296	7776	46656	279936	1679616	10077696

The index or exponent of a power is the number denoting the height or degree of that power, and it is of more than the number of multiplication used in producing the same; so it is the index or exponent of the 1st power, or Root; 2, of the 2nd power, or Square; 3, of the 3rd power, or Cube; 4, of the 4th power, and so on.

Powers that are to be raised are usually denoted by placing the index above the Root or first power, so,—

$$2^2 = 4, \text{ is the 2nd power of } 2;$$
$$2^3 = 8, \text{ is the 3rd power of } 2;$$
$$2^4 = 16, \text{ is the 4th power of } 2;$$
$$540^4 = \text{the 4th power of 540, \&c.}$$

When two or more powers are multiplied together, their product is that power whose index is the sum of the exponents of the factors or powers multiplied; or the multiplication of the powers answers to the addition of the indices; thus, in the following powers of 2:—

	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*
	2	4	8	16	82	64	128	256	512	1024
or,	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}

here, $4 \times 4 = 16$, and $2 + 2 = 4$, its index.
and $8 \times 16 = 128$, and $3 + 4 = 7$, its index.
also, $16 \times 64 = 1024$, and $4 + 6 = 10$, its index.

OTHER EXAMPLES.

(*1st.*) What is the 2nd power of 45?

45
45
225
180
2025 *Answer.*

(*2nd.*) What is the 3rd power of 3·5?

3·5
3·5
175
105
1225
3·5
6125
3675
42·875 *Answer.*

(*3rd.*) What is the square of $\frac{2}{3}$?

$\frac{2}{3} \times \frac{2}{3} = \frac{4}{9}$, *Answer.*

(*4th.*) What is the 3rd power of $\frac{5}{9}$?

$\frac{5}{9} \times \frac{5}{9} \times \frac{5}{9} = \frac{125}{729}$, *Answer.*

(*5th.*) What is the square of 4·16?

4·16
4·16
2496
416
1664
17·3056 *Answer.*

(*6th.*) What is the 5th power of ·029?

·029
·029
261
058
·000841
·029
7569
1682
·000024389
·029
219501
48778
·000000707281
·029
6365529
1414562
·000000020511149, *Answer.*

(*7th.*) What is the 4th power of $\frac{3}{4}$?

$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{81}{256}$, *Answer.*

EVOLUTION.

Evolution, or the reverse of Involution, is the extracting or finding the Roots of any given powers.

The Root of any number or power is such a number as being multiplied by itself a certain number of times will produce that power, thus:—

> 2 is the square-root or 2nd root of 4, *because* $2^2 = 2 \times 2 = 4$; and
> 3 is the cube-root or 3rd root of 27, *because* $3^3 = 3 \times 3 \times 3 = 27$;

Any power of a given number or root may be found exactly, namely, by multiplying the number continually into itself. But there are many numbers of which a proposed root can never exactly be found, yet by means of Decimals we may approximate, or approach, towards the root, to any degree of exactness.

These roots which only approximate are called *surd* roots, but those which can be found quite correct are called *rational* roots; thus, the Square-root of 3 is a *surd* root; but the Square-root of 4 is a *rational* root, being equal to 2; also the Cube-root of 8 is a *rational* root, being equal to 2; but the Cube-root of 9 is *surd*, or irrational.

Roots are sometimes denoted by writing the character $\surd$ before the power, with the index of the root against it; thus, the 3rd root of 20 is expressed by 3-20ths; and the Square-root, or 2nd root, of it is $\surd\ 20$,—the index 2 being always omitted when only the Square-root is designed.

When the power is expressed by several numbers with the sign + or — between them, a line is drawn from the top of the sign over all the parts of it; thus, the 3rd root of 458 — 12 is $\sqrt[3]{45 - 12}$, or thus, $\sqrt[3]{(45 - 12)}$, enclosing the numbers in parentheses.

But all roots are now often designed like powers with fractional indices; thus, the Square-root of 8 is $8^{\frac{1}{2}}$, Cube-root of 25 is $25^{\frac{1}{3}}$, and the 4th root of 45—18 is $\overline{45 - 18}^{\frac{1}{4}}$, or, $(45 - 18)^{\frac{1}{4}}$.

SQUARE-ROOT.

TO EXTRACT THE SQUARE-ROOT.

DIVIDE the given number into periods of two figures each, by setting a point over the place of units, another over the place of hundreds, and so on, over every second figure, both to the left hand in Integers, and to the right in Decimals.

Find the greatest Square in the first period on the left hand, and set its root on the right hand of the given number, after the manner of a Quotient figure in Division. Subtract the Square thus found from the said period, and to the Remainder annex the two figures of the next following period for a Dividend.

Double the root above mentioned for a Divisor; and find how often it is contained in the said Dividend, exclusive of its right hand figure; and set that Quotient figure both in the Quotient and Divisor.

Multiply the whole augmented Divisor by this last Quotient figure, and subtract the product from the said Dividend, bringing down to it the next period of the given number for a new Dividend.

Repeat the same process over again, *viz.*, find another new Divisor, by doubling all the figures now found in the root, from which and the last Dividend find the next figure of the root as before, and so on through all the periods to the last.

NOTE I.—The best way of doubling the root to form the new Divisors, is by adding the last figure always to the last Divisors, as appears in the following examples; also, after the figures belonging to the given number are all exhausted, the operation may be continued into Decimals at pleasure by adding any number of periods of ciphers, two in each period.

II.—When the root is to be extracted to many places of figures, the work may be considerably shortened.

Having proceeded in the extraction after the common method, till there be found half the required number of figures in the root, or one figure more, then for the rest divide the last Remainder by its corresponding Divisor, after the manner of the Third Contraction in Division of Decimals.

EXAMPLES.

(1*st.*) What is the square-root of 2025?

```
       .  .
      2025|45  Ans.
      16
    85|425
       425
       ---
       . . .
```

(2*nd.*) What is the square-root of 17·3056?

```
      .  .  .
      17·3056|4·16 + Ans.
      16
    81|130
        81
   826|4956
       4956
       ----
       . . . .
```

(3*rd.*) What is the square-root of ·000729?

```
           .  .
      ·000729|·027 + Ans.
          4
       47|329
          329
          ---
          . . .
```

(4*th.*) What is the square-root of 3?

```
          3|1·73205 + Ans.
          1
       27|200
          189
      343|1100
          1029
       3462|7100
            6924
     346405|1760000
            1732025
            -------
              27975
```

(5*th.*) What is the square-root of 5?

```
          5|2·236067 + Ans.
          4
       42|100
          84
      443|1600
          1329
     4466|27100
          26796
     447206|3040000
            2683236
     4472127|35676400
             31304889
             --------
              4371511
```

(6*th.*) What is the square-root of 6?

```
          6|2·449489 + Ans.
          4
       44|200
          176
      484|2400
          1936
     4889|46400
          44001
     48984|239900
           195936
     489888|4396400
            3919104
     4898969|47729600
             44090721
             --------
              3638879
```

(7*th.*) •What is the square-root of 11 ?

11|3·316624 + *Ans.*
9
63|200
189
661|1100
661
6626|43900
39756
66326|414400
397956
663322|1644400
1326644
6633244|31775600
26532976
5242624

(8*th.*) What is the square-root of 7 ?

7|2·645751 + *Ans.*
4
46|300
276
524|2400
2096
5285|30400
26425
52907|397500
370349
529145|2715100
2645725
5291501|6937500
5291501
1645999

(9*th.*) What is the square-root of 10 ?

10|3·162277 + *Ans.*
9
61|100
61
626|3900
3756
6322|14400
12644
63242|175600
126484
632447|4911600
4427129
6324547|48447100
44271829
4175271

(10*th.*) What is the square-root of 30 ?

30|5·477225 + *Ans.*
25
104|500
416
1087|8400
7609
10947|79100
76629
109542|247100
219084
1095442|2801600
2190884
10954445|61071600
54772225
6299375

(11*th.*) What is the square-root of 12 ?

12|3·464101 + *Ans.*
9
64|300
256
686|4400
4116
6924|28400
27696
69281|70400
69281
6928201|11190000
6928201
4261799

(12*th.*) What is the square-root of 45 ?

45|6·708203 + *Ans.*
36
127|900
889
13408|110000
107264
134162|273600
268324
13416403|52760000
40249209
12510791

(13*th.*) What is the square-root of 325·1846725 ?

325·1846725|18·032877 + *Ans.*
1
28|225
224
3603|11846
11809
36062|103772
72124
360648|3164850
2885184
3606567|27966600
25245969
36065747|272063100
252460229
19602871

RULES FOR SQUARE-ROOTS OF VULGAR FRACTIONS AND MIXED NUMBERS.

FIRST prepare all Vulgar Fractions, by reducing them to their least terms, both for this and all other roots; then,—

First,—Take the root of the Numerator and of the Denominator for the respective terms of the root required; and this is the best way if the Denominator be a complete power, but if it be not, then,—

Second,—Multiply the Numerator and Denominator together; take the root of the product,—this root being made the Numerator to the Denominator of the given fraction, or made the Denominator to the Numerator of it, will form the fractional root required; that is,—

$$\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}} = \frac{\sqrt{ab}}{b} = \frac{a}{\sqrt{ab}}$$

And this rule will serve whether the root be finite or infinite.

Third,—Or reduce the Vulgar Fraction to a Decimal, and extract its root.

Fourth,—Mixed Numbers may be either reduced to Improper Fractions, and extracted by the First or Second Rule, or the Vulgar Fraction may be reduced to a Decimal, then joined to the Integer, and the root of the whole extracted.

EXAMPLES.

(1*st.*) What is the root of $\frac{25}{36}$?

$$\frac{25}{36} = \frac{5}{6}, \textit{ Ans.}$$

(2*nd.*) What is the root of $\frac{27}{147}$?

$$\frac{27}{147} = \frac{9}{49} = \frac{3}{7}, \textit{ Ans.}$$

(3*rd.*) What is the root of $\frac{9}{12}$?

$$\frac{9}{12} = \frac{3}{4} = {\cdot}75 = 8{\cdot}66025, \textit{ Ans.}$$

```
Or,  ·75|·866025
      64
    -----------
    166|1100
      6|996
    -------------
    1726|10400
       6|10356
    ------------------
     173202|440000
          2|346400
    ----------------------
     1732045|9359600
              8660225
             --------
               699375
```

(*4th.*) What is the root of $\frac{5}{12}$?

$\frac{5}{12}$ = ·416666 = ·645497, *Ans.*

```
      ·416666|·645497 +
       36
    124|566
      4|496
   1285|7066
      5|6425
  12904|64166
      4|51616
 129089|1255066
      9|1161801
1290987|9326566
        9036909
         289657
```

(*5th.*) What is the root of $17\frac{3}{8}$?

$17\frac{3}{8}$ = 17·3750 = 4·168333, *Ans.*

```
      17·3750|4·168333
      16
     81|137
      1| 81
    826|5650
      6|4956
   8328|69400
      8|66624
  83363|277600
      3|250089
 833663|2751100
      3|2500989
 833666|25011100
        24909989
         1001111
```

By means of the Square-root, also, may readily be found the 4th root, or the 8th root, or the 16th root, &c., that is, the root of any power whose index is some power of the number 2,—namely, by extracting so often the Square-root as is denoted by that power 2; that is, two extractions for the 4th root, 3 for the 8th, and so on.

EXAMPLE.

What is the 4th root of 97·41?

```
       97·41|9·8696504
       81
     188|1641
       8|1504
    1966|13700
       6|11796
   19729|190400
       9|177561
  197386|1283900
       6|1184316
 1973925|9958400
       5|9869625
19739304|88775000
          789572016
           98177984
```

```
 9·8696504|3·141599, Ans.
 9
    61| 86
     1| 61
   624|2596
     4|2496
  6281|10050
     1| 6281
 62825|376940
     5|314125
628309|6281500
     9|5654781
6283189|62671900
        56548701
         6123199
```

CUBE ROOT.

To Extract the Cube-root by the common Rule.

First.—Having divided the given number into periods of three figures each, (by setting a point over the place of units, and also over every third figure from thence to the left hand in Whole Numbers, and to the right in Decimals,) find the nearest less Cube to the first period; set its root in the Quotient, and subtract the said Cube from the first period to the Remainder; bring down the second period, and call this the Resolvend.

Second.—To three times the Square of the root just found, add three times the root itself, setting this one place more to the right than the former, and call this sum the Divisor; then divide the Resolvend, wanting the last figure by the Divisor for the next figure of the root, which annex to the former, calling this last figure *e*, and the part of the root before found let be called *a*.

Third.—Add all together these three products, namely, thrice *a* square multiplied by *e*, thrice *a* multiplied by *e* square, and *e* cube, setting each of them one place more to the right than the former, and call the sum the Subtrahend, which must not exceed the Resolvend, but if it does, then make the last figure *e* less, and repeat the operation for finding the Subtrahend, till it be less than the Resolvend.

Fourth.—From the Resolvend take the Subtrahend, and to the Remainder join the next period of the given number for a new Resolvend, to which form a new Divisor from the whole root now found, and from thence another figure of the root, as directed in Article 2nd, and so on.

Examples.

(1*st.*) Extract the cube-root of 571482·19.

$3 \times 8^2 = 192$ | 571482·19 | 82·985
$3 \times 8 = 24$ | 512
1944 | 59482 *resolvend*;

[OVER.

$3 \times 8^2 \times 2 =$ 384
$3 \times 8 \times 2^2 =$ 96 } add ;
$2^3 =$ 8
$3 \times 82^2 =$ 20172 |39368 *subtrahend ;*
$3 \times 82 =$ 246 |
201966|20114190 *resolvend ;*
$3 \times 82^2 \times 9 =$ 181548
$3 \times 82 \times 9^2 =$ 19926 } add ;
$9^3 =$ 729
$3 \times 829^2 =$ 2061723 |18354789 *subtrahend ;*
$3 \times 829 =$ 2487|
20619717|1759401000 *resolvend ;*
$3 \times 829^2 \times 8 =$ 16493784
$3 \times 829 \times 8^2 =$ 159168 } add ;
$8^3 =$ 512
$3 \times 8298^2 =$ 206570412 |1650970592 *subtrahend ;*
$3 \times 8298 =$ 24894|
2065729014|108430408000 *resolvend ;*
$3 \times 8298^2 \times 5 =$ 1032856060
$3 \times 8298 \times 5^2 =$ 622350 } add ;
$5^3 =$ 125
103291429625 *subtrahend ;*
5138978375

(2*nd.*) What is the cube-root of 1628·158200?

$3 \times 1^2 =$ 3 |$\dot{1}62\dot{8}{\cdot}15\dot{8}20\dot{0}$|11·764, *Answer.*
$3 \times 1 =$ 03 |1
33 |628 *resolvend ;*
$3 \times 1^2 \times 1 =$ 3
$3 \times 1 \times 1^2 =$ 3 } add ;
$1^3 =$ 1
$3 \times 11^2 =$ 363 |331 *subtrahend ;*
$3 \times 11 =$ 33|
3663|297158 *resolvend ;*
$3 \times 11^2 \times 7 =$ 2541
$3 \times 11 \times 7^2 =$ 1617 } add ;
$7^3 =$ 343
$3 \times 117^2 =$ 41067|270613 *subtrahend ;* [OVER.

$$
\begin{array}{lr|l}
3\times117^2 = & 41067 & 270613 \textit{ subtrahend};\\
3\times117 = & 351 & \\
\hline
 & 411021 & 26515200 \textit{ resolvend};
\end{array}
$$

$$
\left.\begin{array}{lr}
3\times117^2\times6 = & 246402\\
3\times117\times6^2 = & 12636\\
6^3 = & 216
\end{array}\right\}\text{add};
$$

$$
\begin{array}{lr|l}
3\times1176^2 = & 4148928 & 24766776 \textit{ subtrahend};\\
3\times1176 = & 3528 & \\
\hline
 & 41492808 & 1778424000
\end{array}
$$

$$
\begin{array}{lr}
3\times1176^2\times4 = & 16595712\\
3\times1176\times4^2 = & 56448\\
4^3 = & 64\\
\hline
 & 1660135744\\
\hline
 & 118288256
\end{array}
$$

(*3rd.*) What is the cube-root of 1332?

$$
\begin{array}{lr|r|l}
3\times1^2 = & 3 & 1332 & 11{\cdot}00\dot{2}, \textit{ Answer.}\\
3\times1 = & 03 & 1 & \\
\hline
 & 33 & 332 & \textit{resolvend};
\end{array}
$$

$$
\left.\begin{array}{lr}
3\times1^2\times1 = & 3\\
3\times1\times1^2 = & 03\\
1^3 = & 01
\end{array}\right\}\text{add};
$$

$$
\begin{array}{lr|l}
3\times11{\cdot}00^2 = & 3630000 & 331 \textit{ subtrahend};\\
3\times11{\cdot}00 = & 3300 & \\
\hline
 & 36303300 & 1{,}000{,}000{,}000 \textit{ resolvend};
\end{array}
$$

$$
\left.\begin{array}{lr}
3\times11{\cdot}00^2\times2 = & 7260000\\
3\times11{\cdot}00\times2^2 = & 13200\\
2^3 = & 8
\end{array}\right\}\text{add};
$$

$$
\begin{array}{rl}
726132008 & \textit{subtrahend};\\
\hline
273867992 &
\end{array}
$$

To extract the Cube-root by a short way.

First,—By trials, or by the Table of Roots at *p.* 105, &c., take the nearest rational Cube to the given number, whether it be greater or less, and call it the assumed Cube.

Second,—Then say, by the Rule of Three,—As the sum of the given number and double the assumed Cube is to the sum of the assumed Cube and double the given number, so is the root of the assumed Cube to the root required, nearly; or, as the first sum is to the difference of the given and assumed Cube, so is the assumed root to the difference of the roots, nearly.

Third,—Again, by using in like manner the Cube of the root last found as a new assumed Cube, another root will be obtained still nearer, and so on as far as we please,—using always the Cube of the last found root for the assumed Cube.

Examples.

(1*st.*) To extract the cube-root of ·67.

Here by trial we find that the root lies between ·4 and ·5; taking ·4, the assumed cube will be ·64.

$$\begin{array}{lrcrcr}
\text{Then,} & \cdot 64 & & \cdot 67 & & \\
 & 2 & & 2 & & \\
\hline
 & 1\cdot 28 & & 1\cdot 34 & & \\
 & 67 & & 64 & & \\
\hline
 & 1\cdot 95 & : & 1\cdot 98 & :: & \cdot 4 \\
 & & & \cdot 4 & &
\end{array}$$

$$\begin{array}{r|l|l}
1\cdot 95 & 792 & \cdot 40615 \\
 & 780 & \\
\hline
 & \;\;1200 & \\
 & \;\;1170 & \\
\hline
 & \;\;\;\;300 & \\
 & \;\;\;\;195 & \\
\hline
 & \;\;\;\;1050 & \\
 & \;\;\;\;\;975 & \\
\hline
 & \;\;\;\;\;750 &
\end{array}$$

Again, for a second operation, the cube of this root is ·66997619608375, and the process by the latter method will be thus:

```
     ·66997619
             2
     ---------
    1·33995238     ·67
     67            ·66997619
    ----------     ---------
As  2·00995238  :   00002381  : :  ·40615
                      ·40615
                    --------
                    00011905
                  00002381
                00014286
              00009524
            ----------------
            |·00000967043150|·0000048
                   803980952
                   ----------
                   1630621980
                   1607961904          ·40615
                   ----------
                     22660076          ·0000048
                                       --------
                                       ·4061548, Answer.
```

(*2nd.*) To extract the cube-root of ·01.

Here by trial we find that the root lies between ·2 and ·3; taking 2, the assumed cube will be ·008.

```
Then, ·008      ·01
         2        2
      ----     ----
      ·016      ·02
      ·01       ·008
      ----     -----
       ·026  :  ·028 : : ·2
                  ·2
                ----
      ·026|·0056|·215
           0052
           ----
             40
             26
            ---
            140
            130
            ---
             10
```

Again for a second operation, the cube of this root is ·009938375, and the process by the second method will be thus:

·009938375
2 ·01
·01987675 ·009938375
·01 ·000061625 : : 215
·02987675 : 215
000308125
000061625
000123250
·00013249375|·000446
11950700
129867500 215
119509000 ·000446
103605000 215446, *Answer.*
89630250
13974750

TO EXTRACT ANY ROOT WHATEVER.

Let P be the given power or number, n the index of the power, A the assumed power, r its root, R the required root of P, then say,—

As the sum of $n+1$ times A and $n-1$ times P
is to the sum of $n+1$ times P and $n-1$ times A,
so is the assumed root r to the required root R.

Or, as half the said sum of $n+1$ times A and $n-1$ times P is to the difference between the given and assumed powers, so is the assumed root r to the difference between the true and assumed roots, which difference added or subtracted, as the case requires, gives the true root nearly:

$$\text{That is, } \overline{n+1}\,;\ A+\overline{n-1}\,P : \overline{n+1}\,P\ \overline{n-1}\,A :: r : R\,;$$

$$\text{or, } \overline{n+1}\,;\ \tfrac{1}{2}a+\overline{n-1}\ \tfrac{1}{2}P : P \backsim A :: r : R\,; \backsim$$

And the operation may be repeated as often as we please, by using always the last-found root for the assumed root, and its n^{th} power for the assumed power A.

EXAMPLES.

(1*st*.) What is the 3rd root of 2 ?

Here it appears that the 3rd root lies between 1·2 and 1·3; taking 1·2, its 3rd power is 1·728; hence we have $P = 2$, $n = 3$, $a = 1728$, $r = 1{\cdot}2$; now applying to the first formula,—

$$\overline{n+1}\,,a+\overline{n-1}\,P : \overline{n+1}\,.\,P+\overline{n-1}\,.\,a :: r : R$$

$$(\overline{3+1}\times 1{\cdot}728)+(\overline{3-1}\times 2) : (\overline{3+1}\times 2)+\overline{3-1}\times 1{\cdot}728) :: 1{\cdot}2;$$

or

$$(4\times 1{\cdot}728)+(2\times 2) : (4\times 2)+(2\times 1{\cdot}728) :: 1{\cdot}2;$$

$$\text{or } 6{\cdot}912+4 : 8+3{\cdot}456 :: 1{\cdot}2;$$

$$\text{or } 10{\cdot}912 : 11{\cdot}456 :: 1{\cdot}2;$$

$$\begin{array}{r}
1{\cdot}2 \\ \hline
22912 \\
11456 \\ \hline
10{\cdot}912)\ 13{\cdot}7472\ (1{\cdot}259824 \\
10{\cdot}912 \\ \hline
28352 \\
21824 \\ \hline
65280 \\
54560 \\ \hline
107200 \\
98208 \\ \hline
89920 \\
87296 \\ \hline
26240 \\
21824 \\ \hline
44160 \\
43648 \\ \hline
\end{array}$$

By a second operation, the root will be found to be 1·259921, *Ans.*

(2*nd*.) What is the 3rd root of 3214 ?

Here it appears that the 3rd root is between 14·7; taking 14·7, its 3rd power is 3176·523; hence we have $P = 3214$, $n = 3$, $a = 3176{\cdot}523$, $r = 14{\cdot}7$;

$$\text{then, } \overline{n+1}\,\tfrac{1}{2}\,a+\overline{n-1}\,\tfrac{1}{2}\,P : P \backsim a :: r : R \backsim r;$$

$$(3+1\times 1588{\cdot}2615)+(\overline{3-1}+1607) : 37{\cdot}477 :: 14{\cdot}7 :$$

or

$$(4\times 1588{\cdot}2615)+(2+1607) : 37{\cdot}477 :: 14{\cdot}7 :$$

6353·046 + 3214 : 37·477 : : 14·7 ;

or

9567·046 : 37·477 : : 14·7 ;

14·7
262339
149908
37477
|550·91190| 14·7
47835230   ·05758
72559600   14·75758, *Answer.*
66969322
55902780
47835230
80675500
76536368
4139132

(*3rd.*) What is the 4th root of 2 ?

Here we find that the root lies between 1·18 and 1·19; taking 1·18, its 5th power is 1·9387776; hence we have $P = 2$, $n = 4$, $r = 1\cdot18$, and $a = 1\cdot93877776$; then applying to the first formula,—

$$\overline{n+1}.\,a + \overline{n-1}\,P. : n+1.\,P. + n-1.\,A :: r : R.$$

$$(\overline{4+1} \times 1\cdot93877776) + (\overline{4-1} \times 2) + (\overline{4+1} \times 2) + (\overline{4-1} \times 1)\cdot93877776 :: 1\cdot18;$$

or

$$(5 \times 1\cdot93877776) + (3 \times 2) + (5 \times 2) + (3 \times 1\ 93877776) :: 1\cdot18;$$

or

9·6938888 + 6 : 10 + 5·81633328 : : 1·18
15·6938888 : 15·81633328 : : 1·18
1·18
12653066624
1581633328
1581633328
|18·6632732704|1·189206, nearly, *Ans.*
156938888
296938447
156938888
1399995590
1255511104
144484864
1412449992   1007090944
323948720   941633328
813877776   65457616

(*4th.*) What is the 4th root of 97·41 ?

Here it appears that the root lies between 3·1 and 3·2; taking 3·1, its 4th power is 92·3521; hence we have $P = 97{\cdot}41$, $n = 4$, $A = 92{\cdot}3521$, $r = 31$; applying to the second formula,—

$$(\overline{4}+\overline{1} \times 46{\cdot}17605) + (\overline{4-1} \times 48{\cdot}705) : 5{\cdot}0579 :: 3{\cdot}1;$$

or

$$(5 \times 46{\cdot}17605) + (3 \times 48{\cdot}705) : 5{\cdot}0579 :: 3{\cdot}1;$$

or

$$230{\cdot}88025 + 146{\cdot}115 : 5{\cdot}0579 :: 3{\cdot}1;$$

or

230·88025   5·0579 : : 3·1
146·115   3·1
376·99525 :   50579
151737
|15·6794900| 3·1
150798100   ·04159
59968000   3·14·159, *Answer.*
37699525
222684750
188497625
341871250
33929572
25755255

(*5th.*) What is the 5th root of 2 ?

Here it appears that the root lies between 1·14 and 1·15; taking 1·14, its 5th power is 1·9254145824; hence we have $P. = 2$ $n = 5$ $a = 1{\cdot}9254145824$, $r = 1{\cdot}14$; now applying to the second formula,—

$$\overline{n+1}.\tfrac{1}{2}A + \overline{n-1}.\tfrac{1}{2}P : P \sim a :: r : R \sim r\text{; then,}$$

$$(5 + 1 \times {\cdot}9627072912) + (5 - 1 \times 1) : {\cdot}00745854176 :: 1{\cdot}14$$

or

(6 × ·9627072912) + (4 × 1) : ·00745854176 : : 1·14 or 5·7762437472 + 4 : ·00745854176 : : 1·14 : or 9·7762437472 : ·00745854176 : : 1·14
1·14
2983416704
745854176
745854176   1·14
|·00850273760640| ·008697
782099499776   1·148697 *Answer.*
681742708640
586574624832

951680838080
879861937248
71818900832
68437062304
3381838528

(*6th.*) What is the 6th root of 21035·8 ?

Here it appears that the 6th root lies between 5·25 and 5·26; taking 5·25, its 6th power will be 20938·994384765625; hence we have $P = 21035{\cdot}8$, $n = 6$, $A = 20938{\cdot}99438476525$, $r = 5{\cdot}25$; applying to the second formula,—

$n + 1 \times \frac{1}{2} A + n - 1 . \frac{1}{2} P : P \backsim a :: r : R \backsim r$; then,

(6 + 1 × 10469·497192) + (6—1 × 10517·9) : 96·805616 : : 5·25

or

(7 × 10469·497192) + (5 × 10517·9 : 96·805616 : : 5·25;

or

73286·480344 + 52589·5 : 96·805616 : : 5·25;

or

```
125875·980344 : 96·805616 : : 5·25
                 5·25
               ---------
                484028080
               193611232
               484028080
            ---------------
            |508·229484000|   ·00403720
             503503921376   5·25
            ---------------  -----------
                472556262400 5·25403720, Answer.
                377627941032
               ---------------
                 949283213680
                 881131862408
               ---------------
                  68151351272
```

(*7th.*) What is the 6th root of 2 ?

Here it appears that the 6th root lies between 1·12 and 1·13; taking 1·12, its 6th power is 1·973822685184; hence $P = 2$, $n = 6$, $r = 1{\cdot}12$, $a = 1{\cdot}973822685184$; then applying to the first formula,—

$$\overline{n + 1} . A + \overline{n - 1}\, P : \overline{n + 1} . P . + \overline{n - 1} . A :: r : R.$$

$$(\overline{6 + 1} \times 1{\cdot}9738226) + (\overline{6 - 1} \times 2) : (\overline{6 + 1} \times 2) + (\overline{6 - 1} \times 1{\cdot}973822 :: 1{\cdot}12$$

or

(7 × 1·9738226) + (5 × 2) : (7 × 2) + (5 × 1·9738226) : : 1·12

or

13·8167582 + 10 : 14 + 9·869113 : : 1·12

or

23·8167582 : 23·869113 : : 1·12
1·12
47738226
23869113
23869113
|26·73340656| 1·122462, *Answer.*
238167582
291664836
238167582
534972540
476335164
58637376
47633516
11003860
9526704
1477156
1429006
48150
47634
516

(8*th.*) What is the 7th root of 21035·8 ?

Here it appears that the root lies between 4·14 and 4·15; taking 4·14, its 7th power is 20845·02344116754304; hence $P = 21035{\cdot}8$, $n = 7$, $a = 20845{\cdot}02344116754304$, $r = 4{\cdot}14$; applying to the first formula,—

$$\overline{n+1}.\, a + \overline{n-1}\, P : \overline{n+1}.\, P. + \overline{n-1}.\ a :: r : R$$

or

(7 + 1 × 20845·023441) + (7 — 1 × 21035·8
: (7 + 1 × 21035·8) + (7 — 1 × 20845·023441) : :

or

(8 × 20845·023441) + (6 × 21035·8)
: (8 × 21035·8) + (7 — 1 × 20845·023441) : :

or

166760·187528 + 126214·8 : 168286·4 + 125070·140646 : : 4·14

or

292974·987528 : 293356·540646 : : 4·14
4·14
1173426162584
293356540646
1173426162584
|1214496·07827444|4·145391, *Answer.*
1171899950112
42596128162
29297498753
13298629409
11718999502
1579629907
1464874938
114754969
87892496
26862473
26367741
494732
292982
201752

(9*th.*) What is the 7th root of 2 ?

Here it appears that the 7th root is about 1·1, the 7th power of which will be 1·9487171 ; hence $P = 2$, $n = 7$, $a = 1·9487171$, $r = 1·1$; then, applying to the second formula,—

$$\overline{n+1}.\tfrac{1}{2}\,a + n - 1.\tfrac{1}{2}\,P : P \backsim a :: r : R \backsim r$$

(7 + 1 × ·9743585) + (7 − 1 × 1) : ·0512829 : : 1·1 :

or

(8 × ·9743585) + (6 × 1) : 0·512829 : : 1·1 :

or

7·7950680 + 6 : ·0512829 : : 1·1 :

or

13·7950680 : ·0512829 : : 1·1
1·1
·0512829
·0512829
|·056411190|·004089
55180272 1·1
12309180 1·104089 *Answer.*

11036057
1273123
1241559
31564

(10*th.*) What is the 8th root of 21035·8 ?

Here it appears that the 8th root lies between 3·47 and 3·48; taking 3·47, its 8th power is 21020·14939469888852961; hence we have $P = 21035{\cdot}8$, $n = 8$, $A = 21020{\cdot}14939469888852961$, $r = 3{\cdot}47$; applying to the first formula,—

$$n + 1.\, A + \overline{n - 1.}\, P : \overline{n + 1.}\, P. + n - 1.\, A :: r : R.$$

$$(8 + 1 \times 21020{\cdot}149394) + (8 - 1 \times 21035{\cdot}8) :$$

$$(8 + 1 \times 21035{\cdot}8) + (8 - 1 \times 21020{\cdot}149394) ::$$

or

$$(9 \times 21020{\cdot}149394) + (7 \times 21035{\cdot}8) :$$

$$(8 + 1 \times 21035{\cdot}8) + (8 - 1 \times 21020{\cdot}149394) :$$

or

$$189181{\cdot}344546 + 147250{\cdot}6 : 189322{\cdot}2 + 147141{\cdot}045758 :: 347$$

or

$$\begin{array}{r l}
336431{\cdot}944546 : 336463{\cdot}245758 :: 3{\cdot}47 & \\
3{\cdot}47 & \\
\hline
2355242720306 & \\
1345852983032 & \\
1009389737274 & \\
\hline
1167527{\cdot}46278026 & |\,3{\cdot}470322,\ \textit{Answer.} \\
1009295833638 & \\
\hline
158231629142 & \\
134572777818 & \\
\hline
23658851324 & \\
23550234118 & \\
\hline
1086172060 & \\
1009295834 & \\
\hline
76876226 & \\
67286389 & \\
\hline
9589837 & \\
6728630 & \\
\hline
2861207 &
\end{array}$$

(11*th.*) What is the 8th root of 2?

Here it appears that the root is 1·09, the 8th power of which will be 1·9925626416901921; hence $P = 2$, $n = 8$, $a = 1·9925626416901921$, $r = 1·09$; then applying to the second formula,—

$$n + 1.\tfrac{1}{2}\,A + n - 1.\tfrac{1}{2}\,P : P \backsim a :: r : R \backsim r.$$

$$(8 + 1 \times 1·992562) + (8 - 1 \times 2)$$
$$: (8 + 1 \times 2) + (8 - 1 \times 1·992562) :: 1·09$$

or

$$(9 \times 1992562) + (7 \times 2) : (9 \times 2) + (7 \times 1·992562) :: 1·09 :$$

or

$$17·933058 + 14 : 18 + 13·947934 :: 1·09$$

or

$$31·933058 : 31·947934 :: 1·09 :$$

$$\begin{array}{rl}
1·09 & \\
\hline
287531406 & \\
31947934 & \\
\hline
34·82324806 & \!\!|\,1·090507,\ \textit{Answer.} \\
31933058 & \\
\hline
28901900 & \\
28739753 & \\
\hline
1621470 & \\
1596563 & \\
\hline
248170 & \\
223531 & \\
\hline
24639 &
\end{array}$$

(12*th.*) What is the 9th root of 21035·8?

Here it appears that the 9th root is 3·02, the 9th power of which will be 20895·9676196847644117l2; hence $P = 21035·8$, $n = 9$, $A = 20895·67619684767441172$, $r = 3·02$; then applying to the second formula,—

$$n + 1 \times \tfrac{1}{2}\,a + n - 1\tfrac{1}{2}\,P : P \backsim a :: r$$
$$(9 + 1 \times 10447·983809) + (9 - 1 \times 10517·9) : 139·832381 :: 3·02$$

or

(10 × 10447·983809) + (8 × 10517·9) : 139·832381 : : 3·02

or

(10447·983809) + 8143·2 : 139·832381 : : 3·02

or

18862·3038090 : 139·832381 : : 3·02
3·02
279664762
419497143
|422·293790620| ·002238
377246076180 3·02
450477144400 3·022238 *Answer.*
377246076180
732310682200
565869114270
1664415679300
1508984304720
155431374580

(13*th.*) What is the 9th root of 2 ?

Here it appears that the 9th root of 2 is 1·08, the 9th power of which will be 1·99900462710443212 8; hence $P = 2$, $n = 9$, $a =$ 1·999004627104432128, $r =$ 1·08; applying to the second formula,—

$$\overline{n+1}.\tfrac{1}{2}\,a + \overline{n-1}.\tfrac{1}{2}\,P : P \backsim a :: r$$

(9 + 1 × ·999502) + (9 — 1 × ·1) : ·000996 : : 1·08

or

(10 × ·999502) + (8 × 1) : ·000996 : : 1·08
9·995020 + 8 : ·000996 : : 1·08

or

17·995200 : ·000996 : : 1·08
1·08
007968
000996
|0·01075680| ·000059
899760 1·08
175920 1·080059 *Answer.*
161957
13973

A TABLE OF

SQUARES, CUBES, and ROOTS.

NUMBER.	SQUARE.	CUBE.	SQUARE-ROOT.	CUBE-ROOT.
1	1	1	1·0000000	1·000000
2	4	8	1·4142136	1·259921
3	9	27	1·7320508	1·442250
4	16	64	2·0000000	1·587401
5	25	125	2·2360680	1·709976
6	36	216	2·4494897	1·817121
7	49	343	2·6457513	1·912933
8	64	512	2·8284271	2·000000
9	81	729	3·0000000	2·080084
10	100	1000	3·1622777	2·154435
11	121	1331	3·3166248	2·223980
12	144	1728	3·4641016	2·289428
13	169	2197	3·6055513	2·351335
14	196	2744	3·7416574	2·410142
15	225	3375	3·8729833	2·466212
16	256	4096	4·0000000	2·519842
17	289	4913	4·1231056	2·571282
18	324	5832	4·2426407	2·620741
19	361	6859	4·3588989	2·668402
20	400	8000	4·4721360	2·714418
21	441	9261	4·5825757	2·758923
22	484	10648	4·6904158	2·802039
23	529	12167	4·7958315	2·843867
24	576	13824	4·8989795	2·884499
25	625	15625	5·0000000	2·924018
26	676	17576	5·0990195	2·962496
27	729	19683	5·1961524	3·000000
28	784	21952	5·2915026	3·036589
29	841	24389	5·3851648	3·072317
30	900	27000	5·4772256	3·107232
31	961	29791	5·5677644	3·141381
32	1024	32768	5·6568542	3·174802
33	1089	35937	5·7445626	3·207534
34	1156	39304	5·8309519	3·239612
35	1225	42875	5·9160798	3·271066
36	1296	46656	6·0000000	3·301927

SQUARES, CUBES, AND ROOTS.

NUMBER.	SQUARE.	CUBE.	SQUARE-ROOT.	CUBE-ROOT.
37	1369	50653	6·0827625	3·332222
38	1444	54872	6·1644140	3·361975
39	1521	59319	6·2449980	3·391211
40	1600	64000	6·3245553	3·419952
41	1681	68921	6·4031242	3·448217
42	1764	74088	6·4807407	3·476027
43	1849	79507	6·5574385	3·503398
44	1936	85184	6·6332496	3·530348
45	2025	91125	6·7082039	3·556893
46	2116	97336	6·7823300	3·583048
47	2209	103823	6·8556546	3·608826
48	2304	110592	6·9282032	3·634241
49	2401	117649	7·0000000	3·659306
50	2500	125000	7.0710678	3·684031
51	2601	132651	7·1414284	3·708430
52	2704	140608	7·2111026	3·732511
53	2809	148877	7·2801099	3·756286
54	2916	157464	7·3484692	3·779763
55	3025	166375	7·4161985	3·802953
56	3136	175616	7·4833148	3·825862
57	3249	185193	7·5498344	3·848501
58	3364	195112	7·6157731	3·870877
59	3481	205379	7·6811457	3·892996
60	3600	216000	7·7459667	3·914867
61	3721	226981	7·8102497	3·936497
62	3844	238328	7 8740079	3·957892
63	3969	250047	7·9372539	3·979057
64	4096	262144	8.0000000	4·000000
65	4225	274625	8·0622577	4·020726
66	4356	287496	8·1240384	4·041240
67	4489	300763	8·1853528	4·061548
68	4624	314432	8·2462113	4·081656
69	4761	328509	8·3066239	4·101566
70	4900	343000	8·3666003	4·121285
71	5041	357911	8·4261498	4·140818
72	5184	373248	8·4852814	4·160168
73	5329	389017	8·5440037	4·179339
74	5476	405224	8·6023253	4·198336
75	5625	421875	8·6602540	4·217163
76	5776	438976	8·7177979	4·235824
77	5929	456533	8·7749644	4·254321

SQUARES, CUBES, AND ROOTS.

NUMBER.	SQUARE.	CUBE.	SQUARE-ROOT.	CUBE-ROOT.
78	6084	474552	8·8317609	4·272659
79	6241	493039	8·8881944	4·290841
80	6400	512000	8·9442719	4·308870
81	6561	531441	9·0000000	4·326749
82	6724	551368	9·0553851	4·344481
83	6889	571787	9·1104336	4·362071
84	7056	592704	9·1651514	4·379519
85	7225	614125	9·2195445	4·396830
86	7396	636056	9·2736185	4·414005
87	7569	658503	9·3273791	4·431047
88	7744	681472	9·3808315	4·447960
89	7921	704969	9·4339811	4·464745
90	8100	729000	9·4868330	4·481405
91	8281	753571	9·5393920	4·497942
92	8464	778688	9·5916630	4·514357
93	8649	804357	9·6436508	4·530655
94	8836	830584	9·6953597	4·546836
95	9025	857375	9·7467943	4·562903
96	9216	884736	9·7979590	4·578857
97	9409	912673	9·8488578	4·594701
98	9604	941192	9·8994949	4·610436
99	9801	970299	9·9498744	4·626065
100	10000	1000000	10·0000000	4·641589
101	10201	1030301	10·0498756	4·657010
102	10404	1061208	10.0995049	4·672330
103	10609	1092727	10·1488916	4·687548
104	10816	1124864	10·1980390	4·702669
105	11025	1157625	10·2469508	4·717694
106	11236	1191016	10·2956301	4·732624
107	11449	1225043	10·3440804	4·747459
108	11664	1259712	10·3923048	4·762203
109	11881	1295029	10·4403065	4·776856
110	12100	1331000	10·4880885	4·791420
111	12321	1367631	10·5356538	4·805896
112	12544	1404928	10·5830052	4·820284
113	12769	1442897	10·6301458	4·834588
114	12996	1481544	10·6770783	4·848808
115	13225	1520875	10·7238053	4·862944
116	13456	1560896	10·7703296	4·876999
117	13689	1601613	10·8166538	4·890973
118	13924	1643032	10·8627805	4.904868

SQUARES, CUBES, AND ROOTS.

NUMBER.	SQUARE.	CUBE.	SQUARE-ROOT.	CUBE-ROOT.
119	14161	1685159	10·9087121	4·918685
120	14400	1728000	10·9544512	4·932424
121	14641	1771561	11·0000000	4·946088
122	14884	1815848	11·0453610	4·959675
123	15129	1860867	11·0905365	4·973190
124	15376	1906624	11·1355287	4·986631
125	15625	1953125	11·1803399	5·000000
126	15876	2000376	11·2249722	5·013298
127	16129	2048383	11·2694277	5·026526
128	16384	2097152	11·3137085	5·039684
129	16641	2146689	11·3578167	5·052774
130	16900	2197000	11·4017543	5·065797
131	17161	2248091	11·4455231	5·078753
132	17424	2299968	11·4891253	5·091643
133	17689	2352637	11·5325626	5·104469
134	17956	2406104	11·5758369	5·117230
135	18225	2460375	11·6189500	5·129928
136	18496	2515456	11·6619038	5·142563
137	18769	2571353	11·7046999	5·155137
138	19044	2628072	11·7473444	5·167649
139	19321	2685619	11·7898261	5·180101
140	19600	2744000	11·8321596	5·192494
141	19881	2803221	11·8743421	5·204828
142	20164	2863288	11·9163753	5·217103
143	20449	2924207	11·9582607	5·229321
144	20736	2985984	12·0000000	5·241482
145	21025	3048625	12·0415946	5·253588
146	21316	3112136	12·0830460	5·265637
147	21609	3176523	12·1243557	5·277632
148	21904	3241792	12·1655251	5·289572
149	22201	3307949	12·2065556	5·301459
150	22500	3375000	12·2474487	5·313293
151	22801	3442951	12·2882057	5·325074
152	23104	3511808	12·3288280	5·336803
153	23409	3581577	12·3693169	5·348481
154	23716	3652264	12·4096736	5·360108
155	24025	3723875	12·4498996	5·371685
156	24336	3796416	12·4899960	5·383213
157	24649	3869893	12·5299641	5·394690
158	24964	3944312	12·5698051	5·406120
159	25281	4019679	12·6095202	5·417501

SQUARES, CUBES, AND ROOTS.

NUMBER.	SQUARE.	CUBE.	SQUARE-ROOT.	CUBE-ROOT.
160	25600	4096000	12·6491106	5·428835
161	25921	4173281	12·6885775	5·440122
162	26244	4251528	12·7279221	5·451362
163	26569	4330747	12·7671453	5·462556
164	26896	4410944	12·8062485	5·473703
165	27225	4492125	12·8452326	5·484806
166	27556	4574296	12·8840987	5·495865
167	27889	4657463	12·9228480	5·506879
168	28224	4741632	12·9614814	5·517848
169	28561	4826809	13·0000000	5·528775
170	28900	4913000	13·0384048	5·539658
171	29241	5000211	13·0766968	5·550499
172	29584	5088448	13·1148770	5·561298
173	29929	5177717	13·1529464	5·572054
174	30276	5268024	13·1909060	5·582770
175	30625	5359375	13·2287566	5·593445
176	30976	5451776	13·2664992	5·604079
177	31329	5545233	13·3041347	5·614673
178	31684	5639752	13·3416641	5·625226
179	32041	5735339	13·3790882	5·635741
180	32400	5832000	13·4164079	5·646216
181	32761	5929741	13·4536240	5·656652
182	33124	6028568	13·4907376	5·667051
183	33489	6128487	13·5277493	5·677411
184	33856	6229504	13·5646600	5·687734
185	34225	6331625	13·6014705	5·698019
186	34596	6434856	13·6381817	5·708267
187	34969	6539203	13·6747943	5·718479
188	35344	6644672	13·7113092	5.728654
189	35721	6751269	13·7477271	5·738794
190	36100	6859000	13·7840488	5·748897
191	36481	6967871	13·8202750	5·758965
192	36864	7077888	13·8564065	5·768998
193	37249	7189057	13·8924440	5·778996
194	37636	7301384	13·9283883	5·788960
195	38025	7414875	13·9642400	5·798890
196	38416	7529536	14·0000000	5·808786
197	38809	7645373	14·0356688	5·818648
198	39204	7762392	14·0712473	5·828476
199	39601	7880599	14·1067360	5·838272
200	40000	8000000	14·1421356	5·848085

MENSURATION OF SUPERFICIES.

THE Area of any figure is the measure of its surface, or the space contained within the bounds of the surface, without any regard to thickness.

The Area is estimated by the number of Squares contained in the surface, the side of those Squares being either an inch or a foot or yard, &c., and hence the Area is said to be so many square-inches or square-feet or square-yards, &c.

Our ordinary lineal measures, or measures of length, are as in the first table here below, and the annexed table of square-measures is taken from it, by squaring the several numbers :—

LINEAL MEASURES.		SQUARE-MEASURES.	
12 inches, ...	1 foot.	144 inches, ...	1 foot.
3 feet, ...	1 yard.	9 feet, ...	1 yard.
6 feet, ...	1 fathom.	36 feet, ...	1 fathom.
16½ feet, or 5½ yards,..	1 pole or rod.	272¼ feet, or 30¼ yards,	1 pole or rod.
40 poles, ...	1 furlong.	1,600 poles, ...	1 furlong.
8 furlongs, ...	1 mile.	64 furlongs, ...	1 mile.

IN LAND MEASURE.*

40 perches, or square poles, ... 1 rood of land.
4 roods, or 10 square chains, or 160 poles, .. 1 acre.

---

* Land is usually measured by means of a Chain, called Gunter's Chain, the length of which is 4 poles or 22 yards, and contains 100 equal links, each of which measures $\frac{22}{100}$ of a yard or 7·92 inches in length.

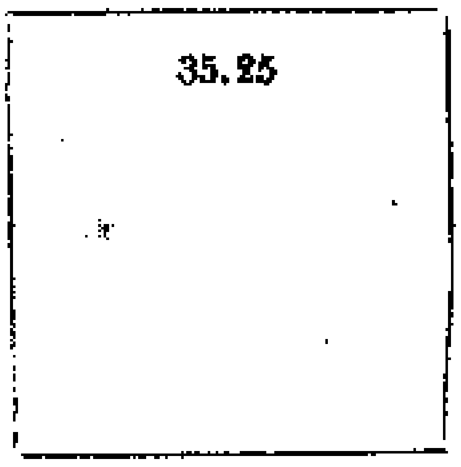
PROBLEM I.

To find the Area of a Parallelogram, whether it be a Square, a Rectangle, a Rhombus, or a Rhomboid.

Rule.—Multiply the length by the Breadth, or Perpendicular Height, and the product will be the Area.

Examples.

1*st.* To find the area of a square whose side is 35·25 chains.

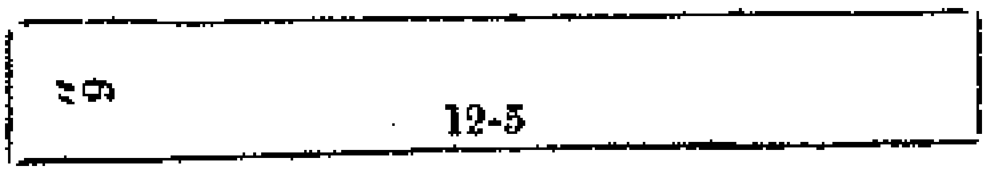


35·25
35·25
17625
7050
17625
10575
10|1242·5625
124·25625
4
1·02500
40
1·

124 *ac.* 1 *rd.* 1 *pch., Answer.*

(2*nd.*) To find the area of a rectangular board whose length is 12·5 feet and breadth 9 inches.

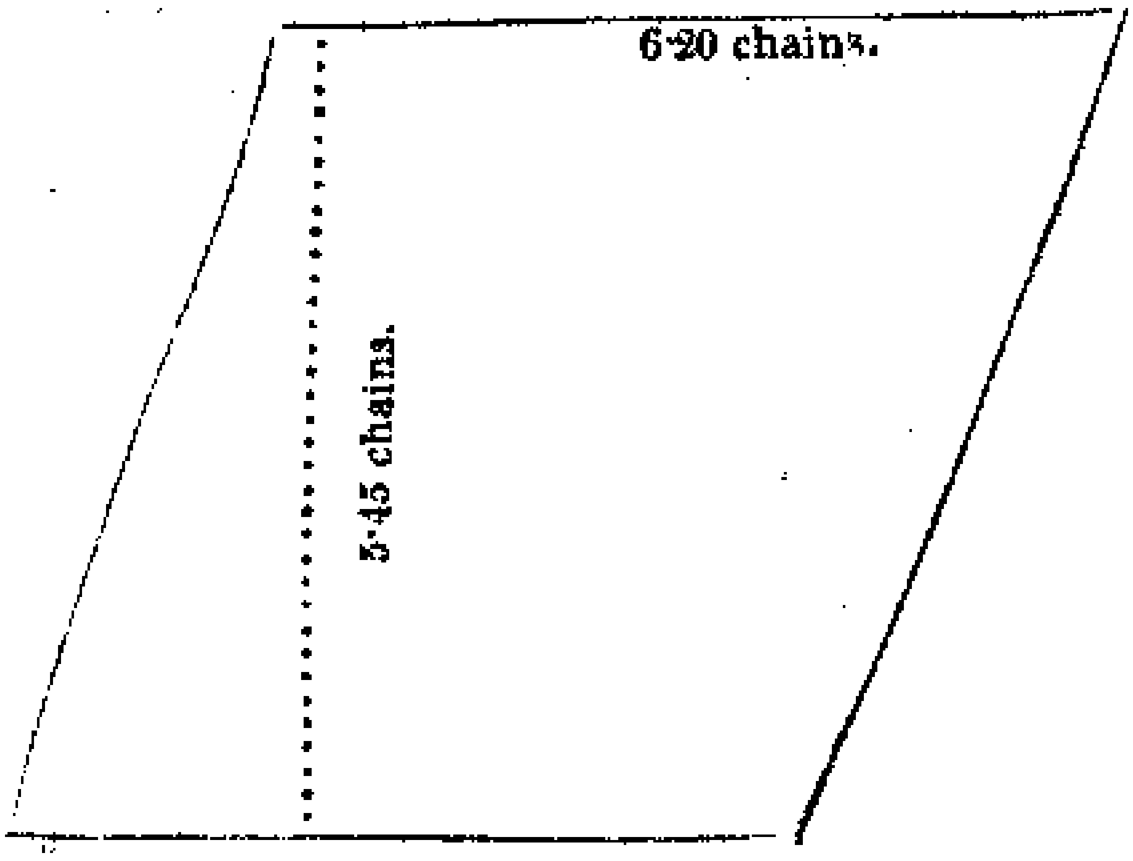
12·6
9
9·4·6″.



9 feet 4′ 6″ *Answer.*

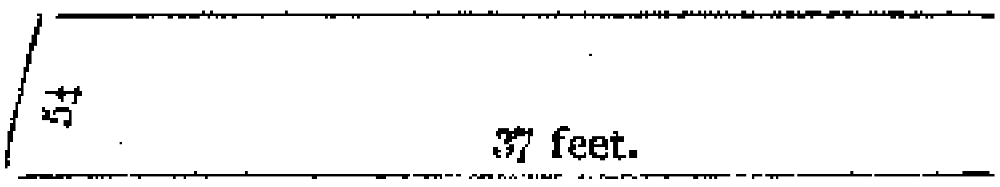
(3*rd.*) To find the area of a rhombus whose length is 6·20 chains and perpendicular height 5·45.

5·45
6·20
10·900
327·0
10 |33·7900
3·379
4
1·516
40
20·640



3 *acs.*, 1 *rd.*, 20 *pchs., Answer.*

(*4th*) To find the square yards of painting in a rhomboid whose length is 37 feet, and breadth $5\frac{1}{4}$ feet.



37
5·25
3675
1575
9|194·25
21·583 = $21\frac{7}{12}$ square yards, *Answer.*

PROBLEM II

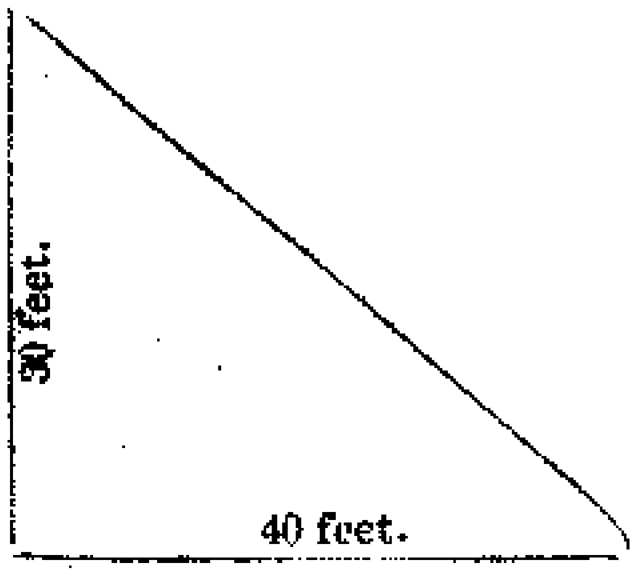
To find the Area of a Triangle.

Rule I.—Multiply the Base by the Perpendicular Height, and take half the product for the Area.

II.—When the three sides only are given:—Add the three sides all together, and take half the sum: from the half sum subtract each side separately; multiply the half sum and the three Remainders continually together, and take the Square-root of the last product for the Area of the Triangle.

Examples.

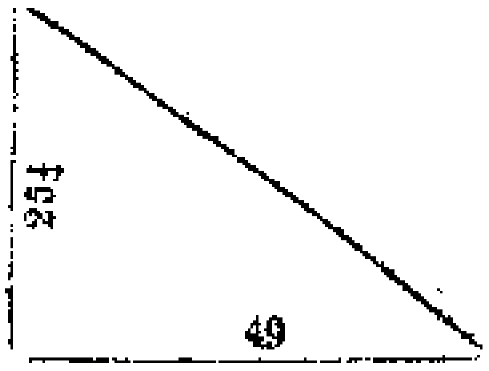
(1*st.*) How many square yards are in a right-angled triangle, whose base is 40, and perpendicular 30 feet?



40 *ft.*
30 *ft.*
2|1200
9| 600 *sq. ft.*
$66\frac{2}{3}$ *yds.*

$66\frac{2}{3}$ square yards, *Answer.*

(2*nd.*) How many square yards contains the triangle whose base is 49 feet, and height $25\frac{1}{4}$ feet?



49 *ft.*
25·25 *ft.*
22725
10100
2|123725 *ft.*
9| 618·625
68·7361, *or* $68\frac{53}{72}$ *sq. yds.*, *Answer.*

(3*rd*.) To find the area of a triangle whose three sides are 20, 30, and 40 chains.

$$\frac{20 + 30 + 40}{2} = \frac{90}{2} = 45 = \tfrac{1}{2}\text{ sum of three sides.}$$

$$45\left\{\begin{array}{l}20 = 25\\30 = 15\\40 = 5\end{array}\right\}\textit{difference};$$

$$\begin{array}{r}
\textit{then } 45\\
25\\
\hline
1125\\
15\\
\hline
16875\\
5\\
\hline
84375|\\
4\\
\hline
49|443\\
441\\
\hline
5804|27500\\
23216\\
\hline
58087|428400\\
406609\\
\hline
580943|2179100\\
1742829\\
\hline
436271
\end{array}
\qquad
\begin{array}{r}
10|290{\cdot}473\ \textit{sq. ch.}\\
\hline
29{\cdot}047\ \textit{acs.}\\
4\phantom{\ \textit{acs.}}\\
\hline
{\cdot}188\ \textit{rds.}\\
40\phantom{\ \textit{rds.}}\\
\hline
7{\cdot}520\ \textit{pchs.}
\end{array}$$

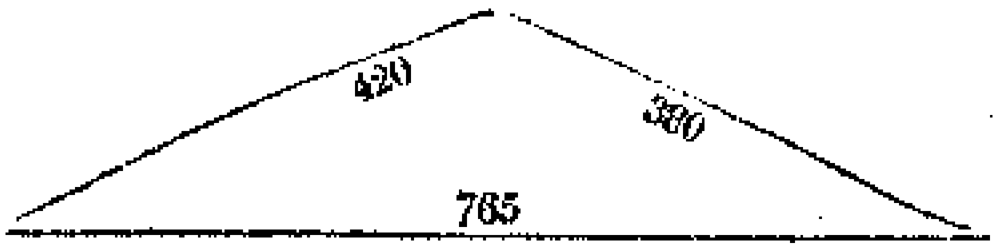
29 *ac.*, 0 *rd.*, 7 *pchs.*, *Answer.*

(4*th*.) How many acres, &c., in the triangle whose 3 sides are 380, 420, 765 yards?

$$\frac{380 + 420 + 765}{2} = \frac{1565}{2} = 782{\cdot}5\ \tfrac{1}{2}\text{ the sum of three sides.}$$

$$782{\cdot}5\left\{\begin{array}{l}380 = 402{\cdot}5\\420 = 362{\cdot}5\\765 = 17{\cdot}5\end{array}\right\}\textit{difference};$$

$$\begin{array}{r}
782{\cdot}5\\
402{\cdot}5\\
\hline
39125\\
15650\\
31300\\
\hline
314956{\cdot}25\\
36{\cdot}25\\
\hline
157478125\\
62991250\\
188973750\\
94486875\\
\hline
114171640{\cdot}625
\end{array}$$



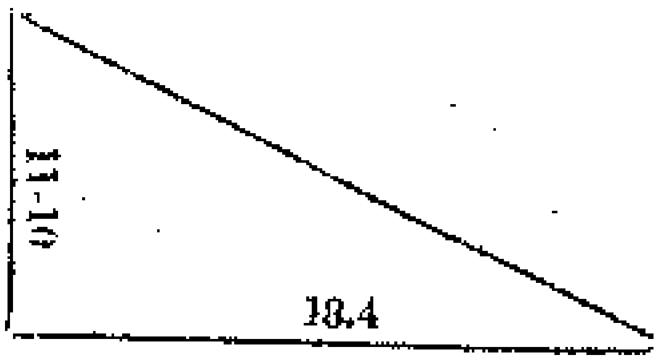
```
        114171640·625
                 17·5
      570858203125
     799201484375
    114171640625
    1998003710·9375|44699·03
    16                 [sqr. yds.
 84|398
  4|336
886|6200
  6|5316
8929|88437
   9|80361
89389|807610
    9|804501
8939803|31099375
       |26819409
        ·4279966
```

```
40|44699·03
11|1117·47575
 11|101·5887
      9·2353
           4
      0·9412
          40
     37·648
```

9 *acs.*, 0 *rd.*, 38 *pchs.*, *Answer.*

(*5th.*) To find the area of the triangle whose base is 18 feet 4 inches and height 11 feet 10 inches.

```
  18 - 4
  11 - 10
 201 - 8
  15 - 3 - 4
2|216 - 11 - 4
  108 - 5′ - 8″
```



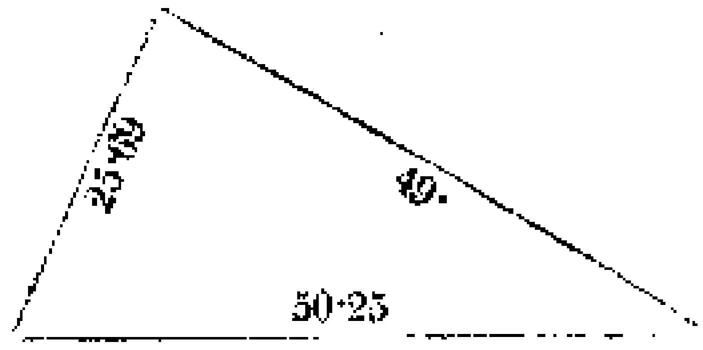
(*6th.*) How many acres, &c., contains the triangle whose three sides are 49·00, 50·25, 25·69 chains?

$$\frac{49 + 50{\cdot}25 + 25{\cdot}69}{2} = \frac{124{\cdot}94}{2} = 62{\cdot}47 - \tfrac{1}{2}$$, the sum of three sides;

$$62{\cdot}47\begin{cases}49{\cdot}00 = 13{\cdot}47\\ 50{\cdot}25 = 12{\cdot}22\\ 25{\cdot}69 = 36{\cdot}78\end{cases}\text{ *difference*;}$$

```
 62·47
 13·47
 43·729
 24988
81211
841·4709
```

[OVER.



841·4709
12·22
16829418
16829418
100976508
10282·774398
36·78
82262195184
71979420786
61696646388
30848323194
378206·44235844·|614·9803 *sqr. ch.*
36
121|182
1|121
1224|6100
4|4896
12289|120444
9|110601
122987|984323
7|983896
1229943|4175844
3689823
486021

10|614·9803
61·49803
4
1·99212
40
39·68480

61 *ac.* 1 *rd.* 39·68 *prchs., Answer.*

PROBLEM III.

To find one Side of a Right-angled Triangle, having the other two Sides given.

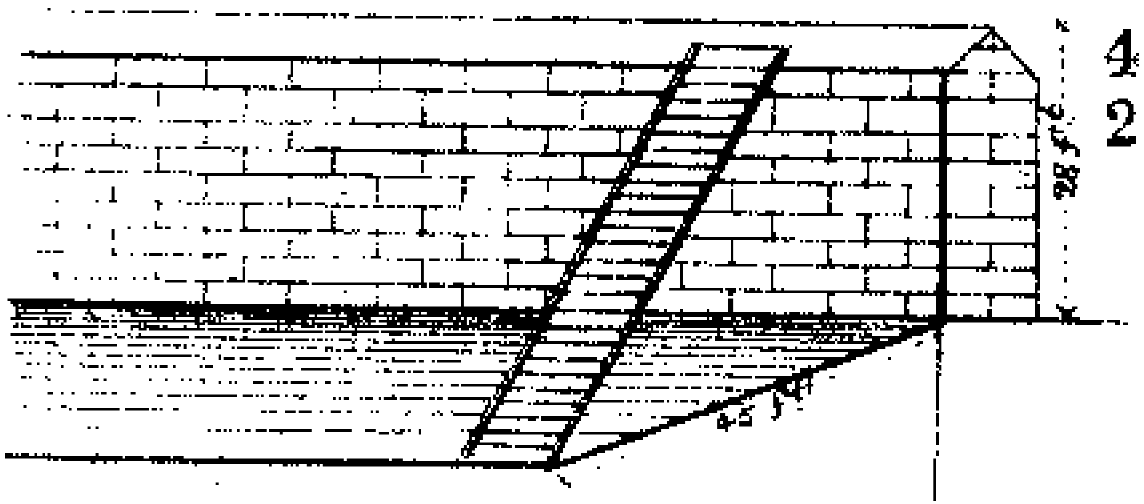
The Square of the Hypothenuse is equal to both the Squares of the two legs; therefore,—

First,—To find the Hypothenuse; add the Squares of the two legs together, and extract the Square-root of the sum.

Second,—To find one leg; subtract the Square of the other leg from the Square of the Hypothenuse, and extract the Square-root of the difference.

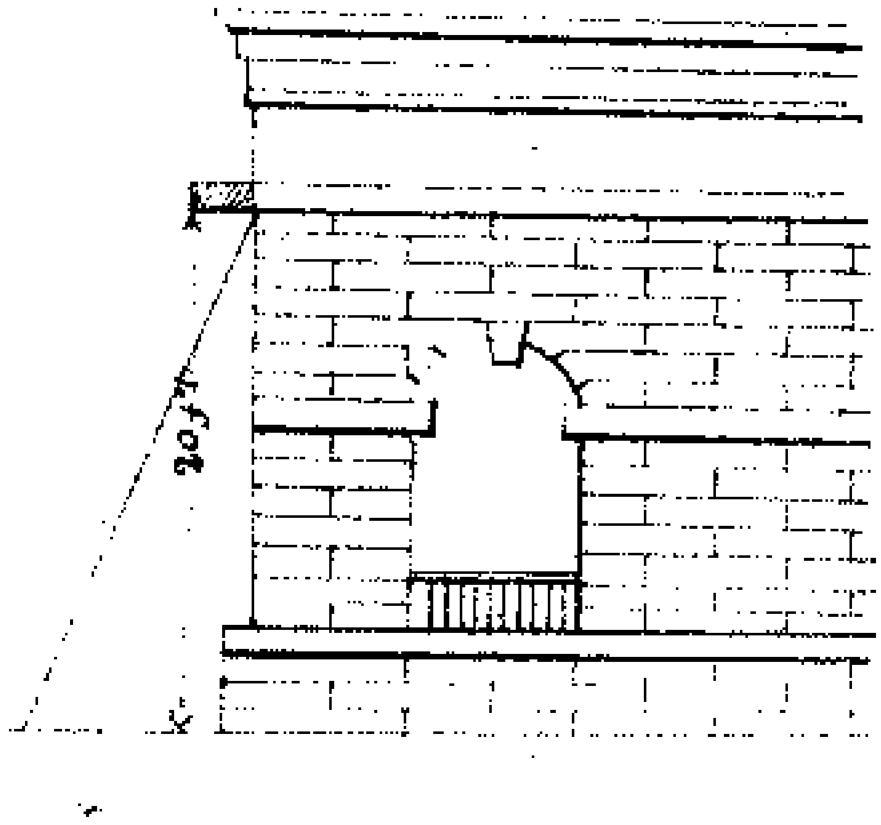
EXAMPLES.

(1*st.*) Required the length of a scaling ladder to reach the top of a wall whose height is 28 feet, the breadth of the ditch before it being 45 feet.



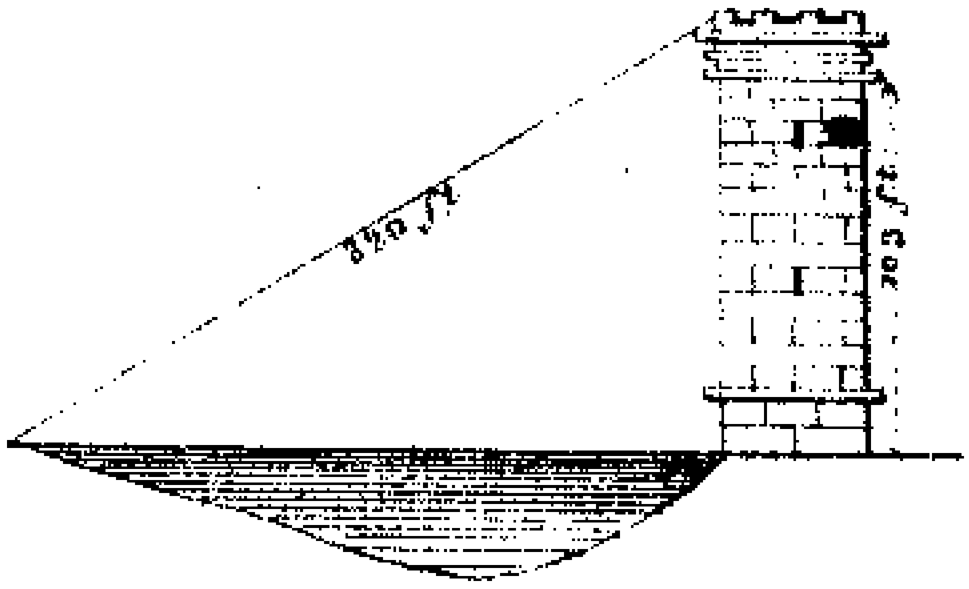
$45^2 = 2025$
$28^2 = 784$
2809 | 53 *feet, Ans.*
25
103 | 309
309

(2*nd.*) To find the length of a shoar, which strutting 12 feet from the upright of a building, may support a jaumb 20 feet from the ground.



$20^2 = 400$
$12^2 = 144$
544 | 23·323807 *feet, Answer.*
4
43 | 144
3 | 129
463 | 1500
3 | 1389
4662 | 11100
2 | 9324
46643 | 177600
3 | 139929
466468 | 3767100
8 | 3731744
46647607 | 35396000
326653360
27306640

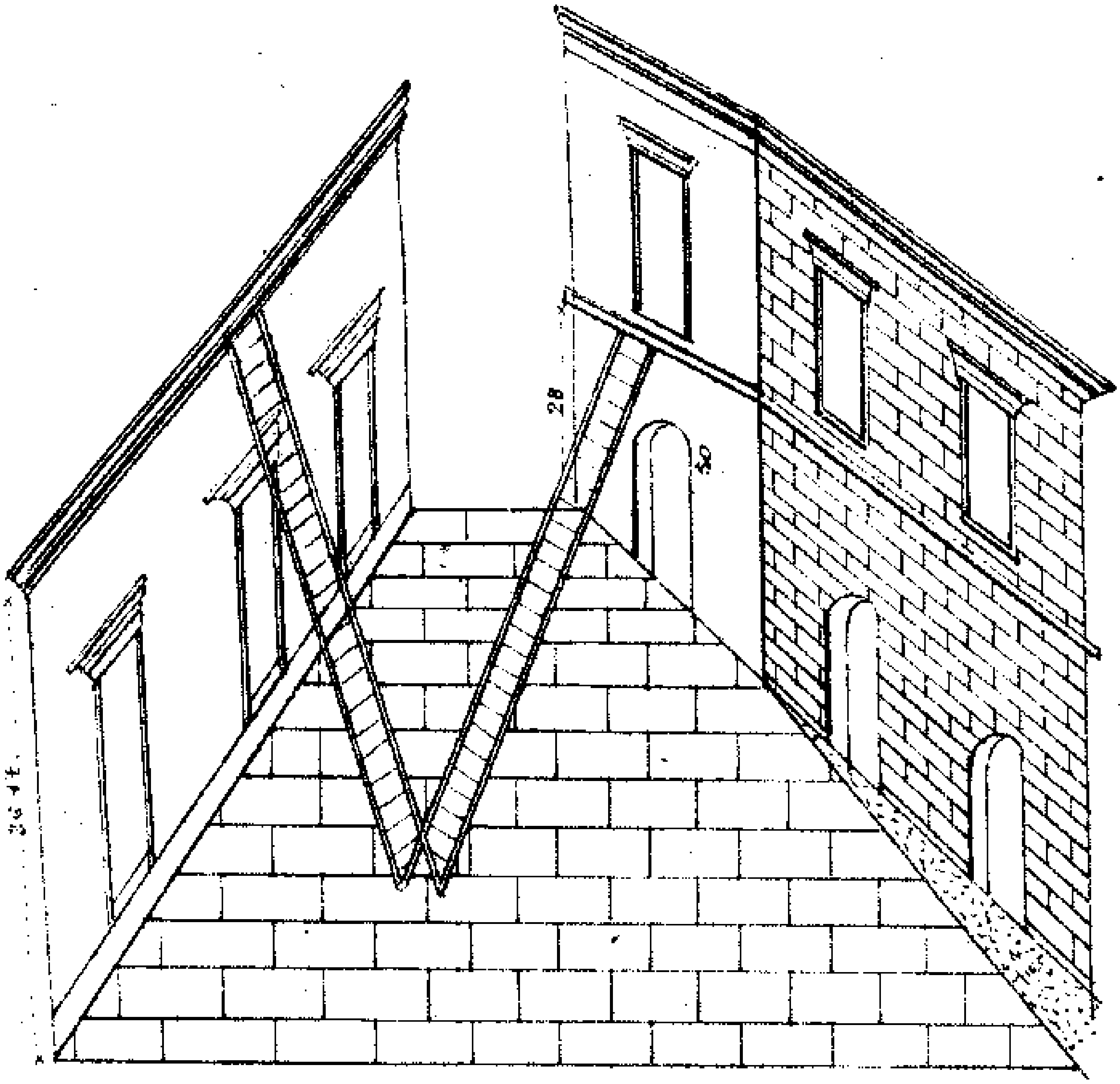
(3*rd.*) A line of 320 feet will reach from the top of a tower standing close by the side of a brook, to the opposite bank: required the breadth of the brook, the height of the tower being 103 feet.



$320^2 = 102400$
$103^2 = 10609$
91791 | 302·97029 *feet, Ans.*
9
602 | 1791
2 | 1204
6049 | 58700

```
6049|58700
   9|54441
---------------
60587|425900
    7|424109
-------------------
6059402|17910000
      2|12118804
---------------------
60594049|579119600
          545346441
          ---------
           33773159
```

(4th.) A ladder of 50 feet long being placed in a street, reached a window 28 feet from the ground on one side, and by turning the ladder over, without removing the foot out of its place, it touched a moulding 36 feet high on the other side; required the breadth of the street.



$50^2 = 2500$
$36^2 = 1296$

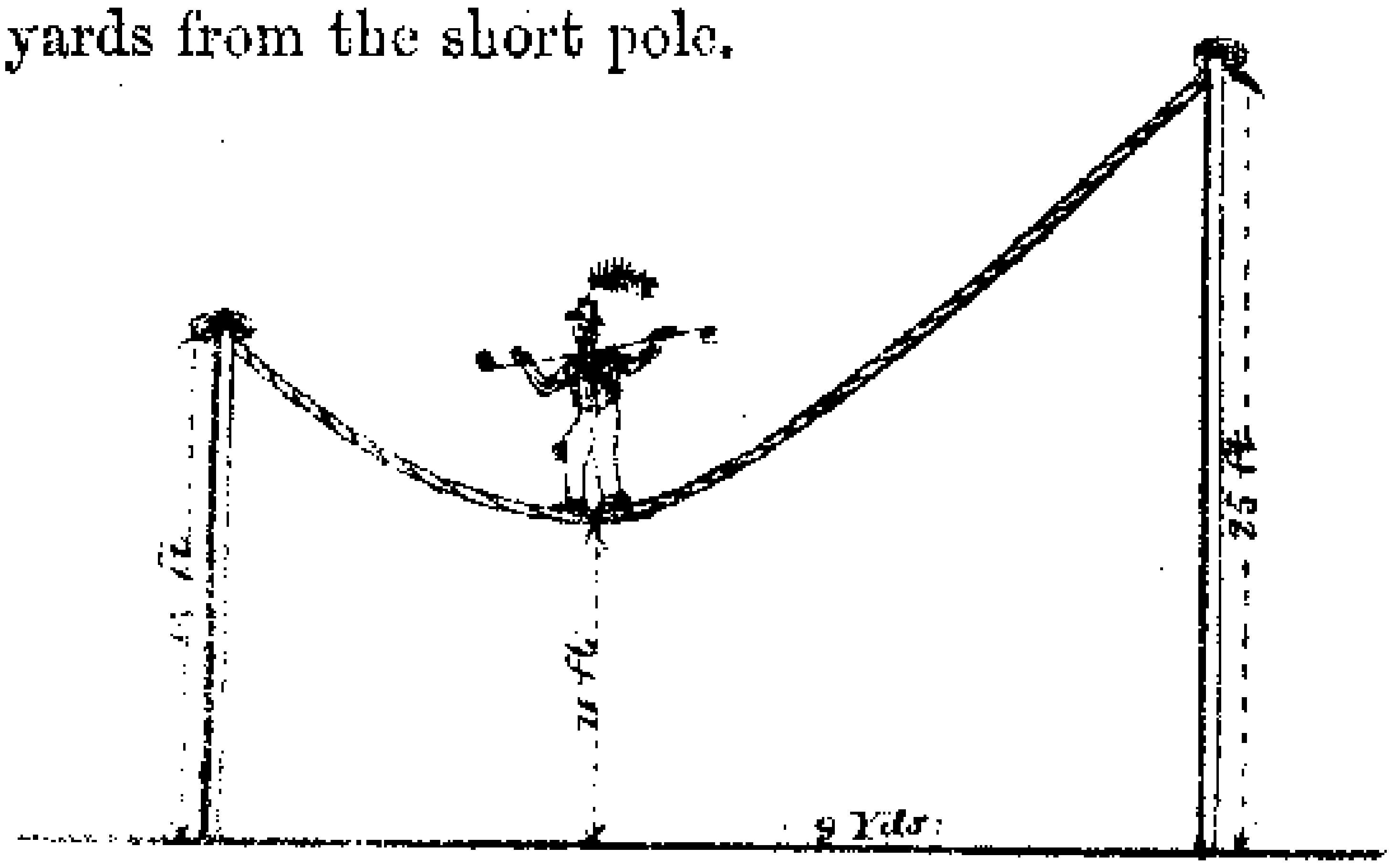
1204|34·698703
9
64|304
4|256
686|4800
6|4116
6929|68400
9|62361
69388|603900
8|555104
693967|4879600
7|4857769
69397403|218310000
3|208192209
69397406|10117791

$50^2 = 2500$
$28^2 = 784$

1716|41·424631
16
81|116
1| 81
824|3500
4|3296
8282|20400
2|16564
82844|383600
4|331376
828486|5222400
6|4960916
8284923|26148400
3|24854769
8284926|129363100
82884926
46478174

34·698703
41·424631
76·123334, *Answer.*

(*5th.*) Suppose a slack-rope has its extremities fastened to the tops of two perpendicular poles whose altitudes are 25 and 15 feet, and distance 9 yards; then, if a mountebank walking on the rope breaks it, and falls 11 feet, find the length of the rope, supposing the mountebank to fall on the ground at a distance of 4 yards from the short pole.


15 ft.
11 ft.
25 ft.
9 Yds.

```
12² = 144                          15² = 225
 4² =  16                          14² = 196
      160|12·649                         421|20·518
      1                                  4
     22|60                            405|2100
      2|44                              5|2025
    246|1600                          4101|7500
      6|1476                              1|4101
   2524|12400                        41028|339900
      4|10096                              328224
  25289|230400                              11636
        227601
         02799

               12·649
               20·518
               33·167 Answer.
```

PROBLEM IV.

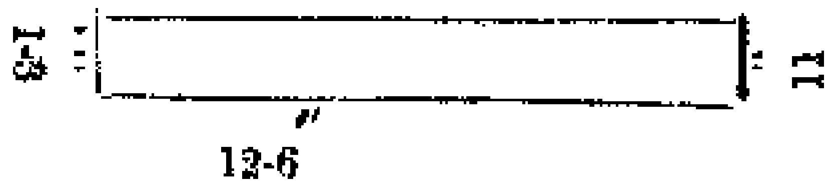
To find the Area of a Trapezoid.

Note.—A Trapezoid is a figure that has only one pair of opposite sides parallel.

Rule.—Multiply the sum of the two parallel sides by the perpendicular distance between them, and take half the product for the Area.

Examples.

(1*st.*) How many square feet contains the plank whose length is 12 feet 6 inches, the breadth at the greater end 1 foot 3 inches, and at the less end 11 inches?



```
  1 - 3
     11
  2 - 2
  12 - 6
  26 - 0
  1 - 1
2|27 - 1
  13 - 6½, Answer.
```

(2*nd.*) Required the area of a trapezoid, the paralled sides being 21 feet 3 inches and 18 feet 6 inches, and the difference between them 8 feet 5 inches.

21 - 3
18 - 6
39 - 9
8 - 5
318 - 0
16 - 6 - 9
2|334 - 6 - 9
167 - 3 - 4 - 6

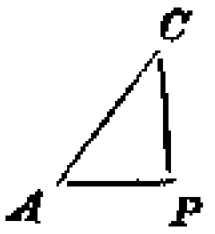
167 *ft.* $\overset{ins.\ ''\ '''}{3\text{-}4\text{-}6}$, *Answer.*

(3*rd.*) In measuring along on one side, *AB*, of a quadrangular field, that side and the two perpendiculars upon it from the opposite corners measured as below, required the contents.

chains.
AP = 1·10
AQ = 7·45
AB = 11·10
PC = 3·52
QD = 5·95

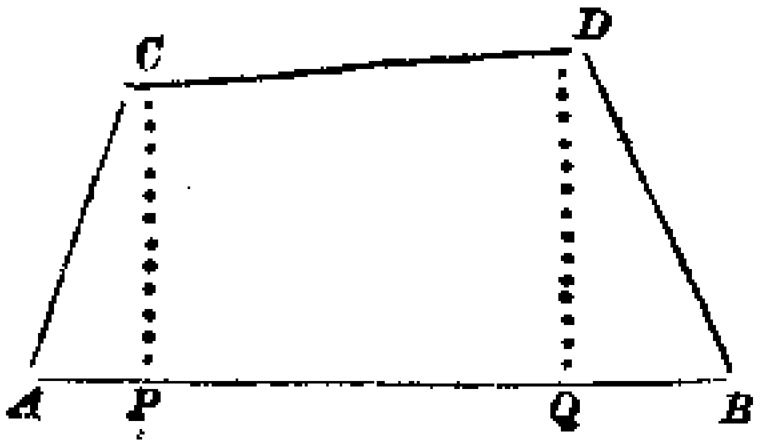
AB — *AQ*
or 11·1—7·45
= 3·65 *BQ*

3·52 = *PC*
1·1 = *AP*
2|3·872
1·936 =



3·65 = *QB*
5·95 = *QD*
1825
3285
1825
2|21·7175
10·85875

3·52 = *PC*
5·95 = *QD*
9·47
6·35 = *PQ*
4735
2841
5682
2|60·1345
30·06725 = *PCDQ*
10·85875 = *QDB*
1·9360 = *ACP*
10|42·86200
4·2862
4
1·1448
40
5·792



4 *ac.*, 1 *rd.* 57·92 *pchs. Answer.*

PROBLEM V.

To find the Area of a Trapezium.

NOTE.—A Trapezium is a quadrilateral figure whose sides are not parallel.

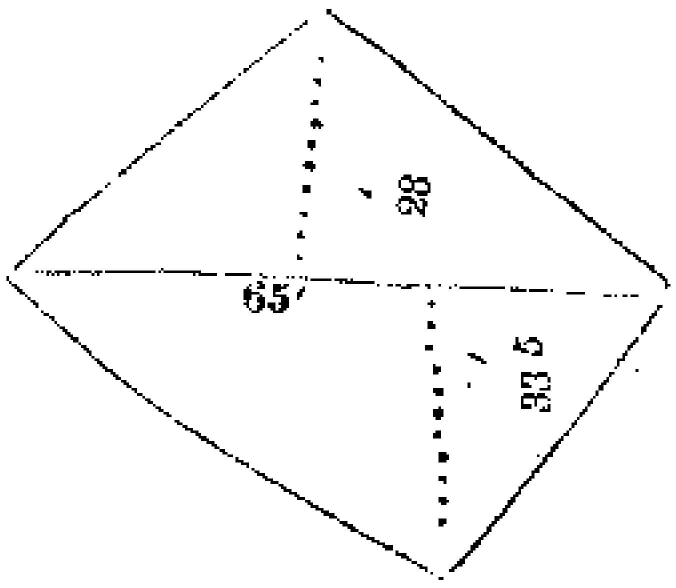
CASE I.—For any Trapezium:—Divide it into two Triangles by a Diagonal; then find the Areas of these Triangles, and add them together.

NOTE.—If two Perpendiculars be let fall on the Diagonal from the other two opposite Angles, the sum of these Perpendiculars being multiplied by the Diagonal, half the product will be the Area of the Trapezium.

CASE II.—When the Trapezium can be inscribed in a Circle:—Add the four sides together, and take half the sum, and subtract each side separately from the half sum; then multiply the four Remainders continually together, and the Square-root of the last product will be the Area of the Trapezium.

EXAMPLES.

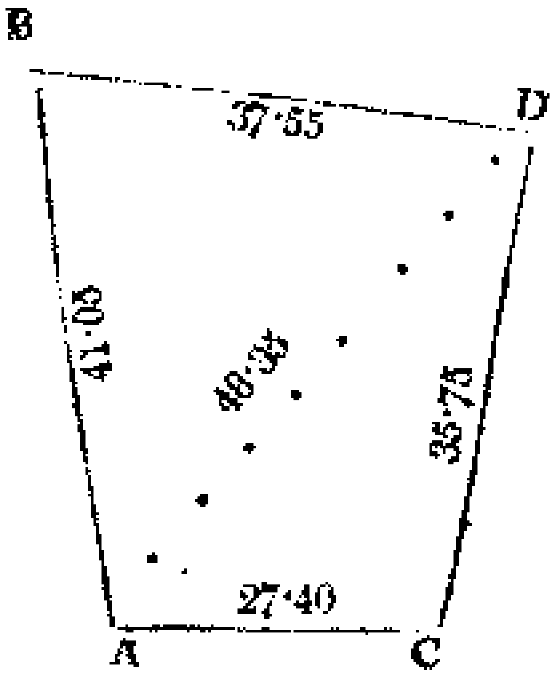
(1*st.*) How many square yards of paving are in the trapezium whose diagonal is 65 feet, and the two perpendiculars let fall on it, 28 and 33·5 feet?



33·5
28·
61·5
65
3075
3690
2|3997 5
9|1998·75
222·083 + 222·083 *sqr. yds., Ans.*

(2*nd.*) What is the area of a trapezium whose south side is 27·40 chains; east side, 35·75 chains; north side, 37·55 chains; west side, 41·05 chains; and the diagonal from south-west to north-east, 48·35 chains?

			48·35
63 475	63·475	63·475	41·05
48·35	41·05	37·55	37·55
15·125	22·425	25·925	2|126·95
			63·475



```
                    63·475
                    15·125
                   -------
                   317·375
                   126950
                   63475
                 317375
                 63475
                 -----------
                 960·059375
                     22·425
                 -----------
                4800296875
               1920118750
              3840237500
             1920118750
            1920118750
            ---------------
            21529·331484375
                     25·925
            ---------------
           107646657421875
           43058662968750
         193763983359375
        107646657421875
        43058662968750
        ---------------------
        558147·918732421875|747·092978 chains;
        49
        ------
     144|681
       4 576
   ------------
    1487|10547
       7 10409
   ----------------
  149409|1389187
       9|1344681
  -----------------
 1494182|4450632
       2|2988364
  -------------------
14941849|146226842
       9|134476641
  ----------------------
149418587|1175020118
        7|1045930109
  ------------------------
1494185948|12909000975
          |11953487584
           ------------
             955513391
```

747·092978 chains is the area of the triangle *DAB*;

then, 35·75
48·35
27·40
2 | 111·50
55·75
35·75
20·

55·75
27·40
28·35

55·75
48·35
7·40

55·75
20
1115·
7·4
44600
7805
825100
28·35
41255
24753
66008
16502
233915·85 | 483·648477 the area of △ *ADC;*
16
88 | 739
8 | 704
963 | 3515
3 | 2889
9666 | 62685
6 | 57996
96724 | 468900
4 | 386896
967288 | 8200400
8 | 7738304
9672964 | 46209600
4 | 38691856
96729687 | 751774400
7 | 677107809
967296947 | 7466659100
6771078629
695580471

747·092978
483·648477
10 | 1230·741455
123·0741455
4
0·2965820
4
11·86328

123 *acs.* 0 *rd.* 11·8632 *pchs., Answer.*

(*3rd.*) What is the area of a trapezium whose diagonal is $108\frac{1}{2}$ feet, and the perpendiculars $56\frac{1}{4}$ feet and $60\frac{3}{4}$ feet?

56·25
60·75
117· = *diagonals;*

108·5
117
7595
1085
1085
2|12694·5
6347·25 *feet, Answer.*

(*4th.*) What is the area of a trapezium inscribed in a circle, the four sides being 12, 13, 14, 15?

$12 + 13 + 14 + 15 = 54 \div 2 = 27$

$27 - 15 = 12$
$27 - 14 = 13$
$27 - 13 = 14$
$27 - 12 = 15$

12
13
156
14
2184.
15
32760|180·997237, *Answer.*
1
28|227
8|224
3609|36000
9|32481
36189|351900
9|325701
361987|2619900
7|2533909
3619942|8599100
2|7239884
36199443|135921600
3|108598339
361994467|2732326100
2533961269
198364831

(*5th.*) In the four-sided field *ABCD*, on account of obstructions in the two sides *AB*, *CD*, and in the perpendiculars *BF*, *DE*, the following measures only could be taken, *viz.* the two sides *BC* 265, *AD* 220 yards, the diagonal *AC* 378 yards, and the two distances of the perpendiculars from the ends of the diagonal, namely, *AE* 100 and *CF* 70 yards; required the area in acres, when 4,840 square yards make an acre.

70
70
4900

265
265
1325
1590
530
70225
4900
65325,255·5875 = *BF*;
4
45|253
5|225
505|2825
5|2525
5105|30000
5|25525
51108|447500
8|408864
511167|3863600
7|3578169
5111745|28543100
25558725
2984375

100
100
10000

220
220
4400
440
48400
10000
38400|195·9591 = *DE*;
1
29|284
9|261
385|2300
5|1925
3909|37500
9|35181
39185|231900
5|195925
391909|3597500
9|3527181
3919181|7031900
3919181
3112719

195·9591
255·5875
451·5466 *sum of the perpendiculars*;
378
36123728
31608262
13546398
2|170684·6148

```
     2|170684·6148
4840|85342·3074|17·6327
     4840             4
     36942       2·5308
     33880           40
      30623      21·232
      29040
       15830
       14520
        13107  17 acs. 2 rds. 21 pchs., Answer.
         9680
         34274
         33880
           394
```

PROBLEM VI.

To find the Area of an irregular Polygon.

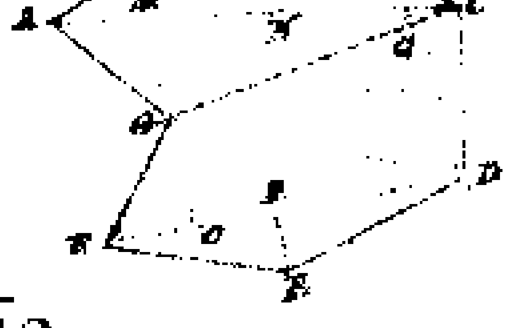
Draw Diagonals dividing the proposed Polygon into Trapeziums and Triangles; then find the Areas of all these separately, and add them together for the contents of the whole Polygon.

Example.

To find the contents of the irregular figure *ABCDEFG*, in which are given the following diagonals and perpendiculars, namely,—

AC = 5·5 *GC* = 4·4 *BN* = 1·8 *EP* = ·8
FD = 5·2 *GM* = 1·3 *GO* = 1·2 *DQ* = 2·3

```
GM = 1·3            GO = 1·2
BN = 1·8            PE =  ·8            GC = 4·4
      3·1                 2·0           DQ = 2·3
      5·5 = AC.           5·2 = FD            132
      155               2|10·40                88
      155                 5·20 area of FGDE;  2|10·12
    2|17·05                                     5·06 area of △ CGD;
    8·525 = area of the trapezoid GABC;         5·20
                                                8·525
                                               18·785 Answer.
```



PROBLEM VII.

To find the Area of a regular Polygon.

RULE I.—Multiply the Perimeter, or sum of its sides, by the Perpendicular falling from the centre of the figure on one of its sides, and half the product will be the Area.

II.—Square the side of the Polygon, multiply that Square by the Multiplier set against its name in the following table, and the product will be the Area.

No. of Sides.	Names.	Multipliers.
3	*Trigon*, or *Equilateral Triangle*, …………	0·4330127
4	*Tetragon*, or *Square*, ……………………… .	1·0000000
5	*Pentagon*, ……………………… … ………	1·7204774
6 *	*Hexagon*, ………………………………………	2·5980762
7	*Heptagon*, ………………………………………	3·6339124
8	*Octagon*, ……… ……………………………	4·8284271
9	*Nonagon*, ………………………………………	6·1818242
10	*Decagon*, ………………………………………	7·6942088
11	*Undecagon*, ……………………………………	9·3656399
12	*Dodecagon*, ……………………………………	11·1961524

EXAMPLES.

(1*st.*) To find the area of the hexagon whose side is 20.

$$\begin{array}{r} 2{\cdot}5980762 \\ 400 = 20^2 \\ \hline 1039{\cdot}23048 \end{array} \textit{ Answer.}$$

*

(2*nd.*) To find the area of the trigon, or equilateral triangle, whose side is 20.

$$\begin{array}{r} 0{\cdot}4330127 \\ 400 = 20^2 \\ \hline 173{\cdot}20508 \end{array} \textit{ Answer.}$$

(3*rd.*) Required the area of the octagon whose side is 20.

$$\begin{array}{r} 4{\cdot}8284271 \\ 400 = 20^2 \\ \hline 1931{\cdot}37084 \end{array} \textit{ Answer.}$$

(4*th.*) What is the area of a decagon whose side is 20.

7·6942088
400 = 20^2
3077·68352 *Answer.*

PROBLEM VIII.

To find the Diameter and Circumference of a Circle, the one from the other.

Rule I.— As 7 is to 22, so is the Diameter to the Circumference.
As 22 is to 7, so is the Circumference to the Diameter.

„ **II.**— As 113 is to 355, so is the Diameter to the Circumference.
As 355 is to 113, so is the Circumference to the Diameter.

„ **III.**— As 1 is to 3·1416, so is the Diameter to the Circumference.
As 3·1416 is to 1, so is the Circumference to the Diameter.

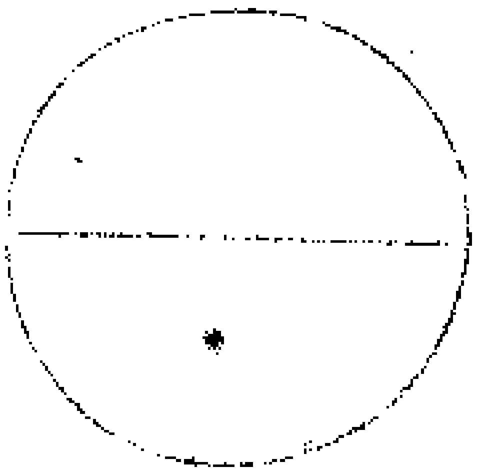
Examples.

(1*st.*) If the diameter of the Earth be 7,958 miles (as it is very nearly), what is the circumference, supposing it to be exactly round?

By Rule 1st.
7 : 22 :: 7958
22
15916
15916
7|175076
25010·857142 *Ans.*

By Rule 2nd.
113 : 355 :: 7958
355
39790
39790
23874
113|2825090
25000·796 *Ans.*

By Rule 3rd.
As 1 : 3·1416 :: 7958
7958
251328
157080
282744
219912
25000·8528 *Ans.*



(*2nd.*) To find the diameter of the globe of the Earth, supposing its circumference to be 25,000 miles.

By Rule 1st.

22 : 7 : : 25000
7
22|175000
$7954\frac{6}{11}$ *Ans.*

By Rule 2nd.

355 : 113 : : 25000
113
75000
25000
25000
355|2825000
7957·746 *Ans.*

By Rule 3rd.

3·1416 : 1 : : 25000
|250000|7957·72 *Ans.*
219912
300880
282744
181360
157080
242800
219912
228880
219912
89680
62832
26748

PROBLEM IX.

To find the Length of any Arc of a Circle.

Rule I.— As 180 is to the number of degrees in the Arc,
So is 3·1416 the Radius to its length.
Or, As 3 is to the number of degrees in the Arc,
So is ·05236 times the Radius to its length.

II.—From 8 times the Chord of half the Arc subtract the Chord of the whole Arc, and $\frac{1}{3}$ of the Remainder will be the length of the Arc nearly.

Examples.

(*1st.*) Required the length of an arc of 12 degrees 10 minutes, or $12\frac{1}{6}$ degrees, the radius being 10 feet.

As 3 : $12\frac{1}{6}$: : ·05236
10
52360
$12\frac{1}{6}$
628320
8726·6
3|6·370466
2·123488 *Ans.*

(*2nd.*) To find the length of an arc whose chord is 6, and the chord of its half is $3\frac{1}{2}$.

3·5 = *chord of half arc;*
8
28 = 8 *times;*
6
3|22 *chord of whole arc;*
$7\frac{1}{3}$ *Answer.*

(*3rd.*) Required the length of the arc whose chord is 8, and the height, *PD*, 3.

Here $\sqrt{4^2 \times 3^2} = 25 = 5 =$ *chord of half arc ;*

8
40
8
3|320
$10\frac{2}{3}$ *Answer.*

(*4th.*) Required the length of the arc whose chord is 6, the radius being 9.

$9^2 = 81$
$3^2 = 9$
72
64
164|800
4|656
1688|14400
8|13504
16965|89600
5|84825
169702|477500
339404
138096

9
8·48528
·51472
·51472
102944
360304
205888
51472
257360
·2649366784

·2649366784
9·
9·2649366784|3·0438358
9
604|2649
4|2416
6083|23336
3|18249
60868|508767
8|486944
608763|2182384
3|1826289
6087665|35609500
30438325
5171175

3·0438358
8
24·3506864
6
3|18·3506864
6·1168954 *Answer.*

PROBLEM X.

To find the Area of a Circle.

The Area of a Circle may be found from the Diameter and Circumference together, or from either of them alone, by the following Rules :—

Rule I.—Multiply the whole Circumference by the whole Diameter, and take ¼th of the product ; or multiply half the Circumference by half the Diameter, and the product will be the answer.

II.—Multiply the Square of the Diameter by ·7854.

III.—Multiply the Square of the Circumference by ·07958.

IV.—As 14 to 11 so is the Square of the Diameter to the Area.

V.—As 88 to 7 so is the Square of the Circumference to the Area

Examples.

(1*st.*) Required the area of a circle, whose diameter is 7 and circumference 22.

By Rule 1.

22
7
4|154
33½ *Ans.*

By Rule 2.

·7854
49
70686
31416
38·4846 *Ans.*

By Rule 3.

·07958
484
31832
63664
31832
38·51672 *As.*

By Rule 4.

As 14 : 11 : : 49
11
14|539
38·5 *Ans.*

By Rule 5.

As 88 : 7 : : 484
7

$$88\left\{\begin{array}{r|r} 11 & 3388 \\ 8 & 308 \end{array}\right.$$

38·5 *Ans.*

(2*nd.*) What is the area of a circle, whose diameter is 1 and circumference 3·1416 ?

By Rule 1.

4|3·1416
·7854

By Rule 2.

$1^2 = 1$
·7854

By Rule 3.

·07958
$3{\cdot}1416^2 = 9{\cdot}86965056$
7895720448
4934825280
8882685504
6908755492
·7854468015648 *Ans.*

By Rule 4.

As 14 : 11 : : 1
11
14|110
·7857 *Ans.*

By Rule 5.

As 88 : 7 : : 9·86965056
7
88 { 11|69·08755392
8| 6·28068672
·78508584 *Ans.*

(*3rd.*) What is the area of a circle whose diameter is 7?

·7854
49
70686
31416
38·4846 *Answer.*

(*4th.*) How many square yards are in a circle whose diameter is $3\frac{1}{2}$ feet?

3·5
3·5
175
105
12·25
·7854
4900
6125
9800
8575
9|9·621150
1·069016 *Answer.*

(*5th.*) How many square feet does a circle contain, the circumference being 10·9956 yards?

10·9956
10·9956
659736
549780
989604
989604
109956
12·09032l936
·07958
96722575488
60451609680
108812897424
84632253552
9·6214781966688
9
86·5933037700192 *Answer.*

PROBLEM XI.

To find the Area of the Sector of a Circle.

NOTE.—A Sector is any part of a Circle which is bounded by an Arc and two Radii drawn to its extremities.

RULE I.—Multiply the Radius, or half the Diameter, by half the Arc of the Sector for the Area; or, multiply the Diameter by the Arc of the Sector, and take one-fourth of the product.

NOTE.—The Arc may be found by Problem IX.

II.—As 360 is to the degrees in the Arc of the Sector, so is the whole Area of the Circle to the Arc of the Sector.

NOTE.—For a Semicircle take one half, for a Quadrant one quarter, &c., of the whole Circle.

EXAMPLES.

(1*st.*) What is the area of a sector whose radius is 9, and the chord of its arc 6?

$9 \times 3 = 27$, *Answer.*

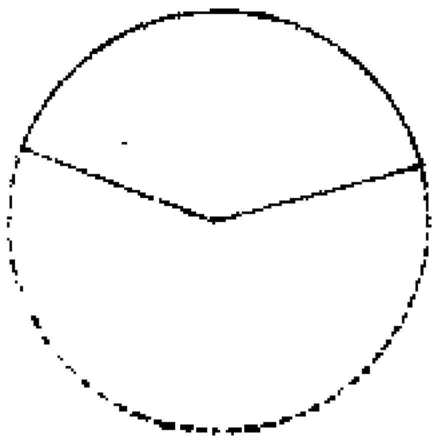
(2*nd.*) What is the area of the sector whose radius is 10, and arc 20?

$10 \times 10 = 100$, *Answer.*

(3*rd.*) Required the area of a sector whose radius is 25, its arc containing 147 degrees, 29 minutes.

As 360 : 147·29 : : 1963·5

·7854
2500 $= 50^2$;
3927000
15708
1963·5000



1963·5
147
137·445
78540
19635
$20 = \frac{1}{3}$ 288634·5
$5 = \frac{1}{4}$ 654·5
$4 = \frac{1}{5}$ 163·625
130·9
$360 \begin{cases} 6 \\ 60 \end{cases}$ 289583·525
48263·9208
804·39868

(4*th.*) To find the area of a quadrant and a semicircle, to the radius 13.

·7854
676 $= 26^2$
47124
54978
47124
4|530·9304
132·7326 *Ans. of the quadrant.*

·7854
676 $= 26^2$
47124
54978
47124
2|530·9304
265·4652 *Ans. of the semicircle.*

PROBLEM XII.

To find the Area of a Segment of a Circle.

Note.—A Segment is any part of a Circle bounded by an Arc and its Chord.

Rule I.—Find the Area of the Sector having the same Arc with the Segment, by the last Problem. Find also the Area of the Triangle formed by the Chord of the Segment and the two Radii of the Sector. Then the sum of these will be the answer when the Segment is greater than a Semicircle, but the Difference will be the answer when it is less than a Semicircle.

II.—To the Chord of the whole Arc add $\frac{4}{3}$ of the Chord of half the Arc, or add the latter Chord and $\frac{1}{3}$ of it more. Multiply the sum by the Versed Sine, or height of the Segment, and take $\frac{4}{10}$ of the product for the Area of the Segment.

III.—Divide the height of the Segment by the Diameter, and find the Quotient in the column of Heights, or Versed Sines,—*vide* following Table. Take out of the corresponding Area in the next column on the right hand, and multiply it by the Square of the Diameter for the answer.

Table of the Areas of Circular Segments.

Height.	*Area of Segment.*	*Height.*	*Area of Segment.*	*Height.*	*Area of Segment.*	*Height.*	*Area of Segment.*	*Height.*	*Area of Segment.*
·01	·00133	·11	·04701	·21	·11990	·31	·20738	·41	·30319
·02	·00375	·12	·05339	·22	·12811	·32	·21667	·42	·31304
·03	·00687	·13	·06000	·23	·13646	·33	·22603	·43	·32223
·04	·01054	·14	·06683	·24	·14494	·34	·23547	·44	·33284
·05	·01468	·15	·07387	·25	·15354	·35	·24498	·45	·34278
·06	·01924	·16	·08111	·26	·16226	·36	·25455	·46	·35274
·07	·02417	·17	·08853	·27	·17109	·37	·26418	·47	·36272
·08	·02944	·18	·09613	·28	·18002	·38	·27386	·48	·37270
·09	·03502	·19	·10390	·29	·18905	·39	·28359	·49	·38270
·10	·04088	·20	·11182	·30	·19817	·40	·29337	50	·39270

EXAMPLES.

(1*st.*) What is the area of the segment whose height is 2 and the chord 20?

(First, by Problem III.)

$\sqrt{10^2 + 2^2} = \sqrt{104} =$ 10·198039 = *chord of half the arc;*

3·399346

13·597385 = $\frac{3}{4}$*ths of ditto;*

20 = *chord of the whole arc;*

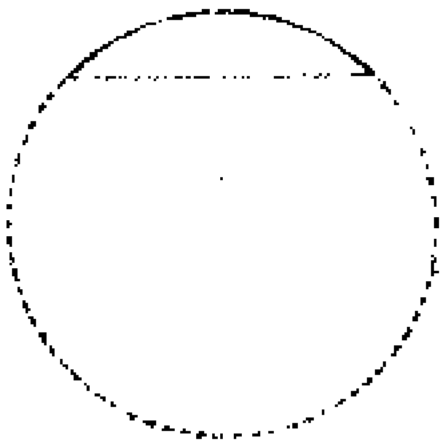
33·597385

2 = *versed sine;*

67·194770

4

268·779080 *Answer.*



(2*nd.*) What is the area of a segment whose height is 18 and diameter of the circle 50?

By Rule 3.

Here, 18 ÷ 50 = ·36 = tab. *versed sine;*

then tab. area to ·36 = ·25455

250 = *diameter;*

127275

5091

636·375 *Answer.*

(3*rd.*) Required the area of the segment whose chord is 16, the diameter being 20.

$10^2 = 100$

$8^2 = 64$

$\sqrt{36} = 6$, *altitude of triangle;*

$10 - 6 = 4$, *altitude of segment;*

chord of $\frac{1}{2}$ *arc* = 8·9442

8

71·5536

chord of arc = 16·

3|55·5536

18·51786 *length of arc;*

20

4|370·3572

92·5893 *area of the sector;*

$8^2 = 64$
$4^2 = 16$
80
64

8·9442 = *chord of* ½ *arc ;*

169|1600
9|1521
1784|7900
4|7136
17884|76400
4|71536
178882|486400
|357764
128636

By Rule 1.

92·5893
48 = *area of triangle ;*
44·5893 *Answer.*

By Rule 3.

·111823
400
44·5893 *Answer.*

PROBLEM XIII.

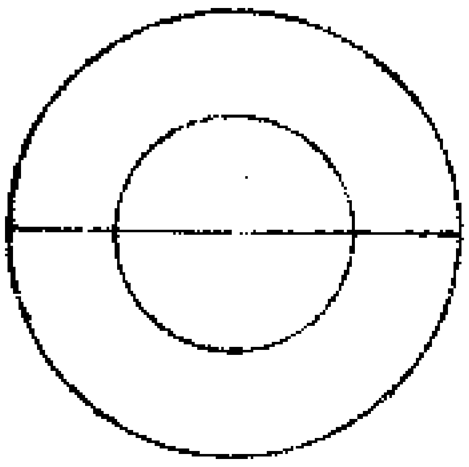
To find the Area of a circular Ring, or Space included between two concentric Circles.

RULE.—Take the Difference between the two Circles for the Ring, or multiply the sum of the Diameters by their Difference, and multiply the product by ·7854 for the answer.

EXAMPLES.

(1*st.*) The diameter of two concentric circles being 20 and 10, required the area of the ring between their circumferences.

20
10
30
10 *difference ;*
300
·7854
235·62 *Answer.*



(2*nd.*) What is the area of a ring, the diameter of whose bounding circles are 6 and 4 ?

4
6
10
2 *difference ;*
20
·7854
15·708 *Answer.*

PROBLEM XIV.

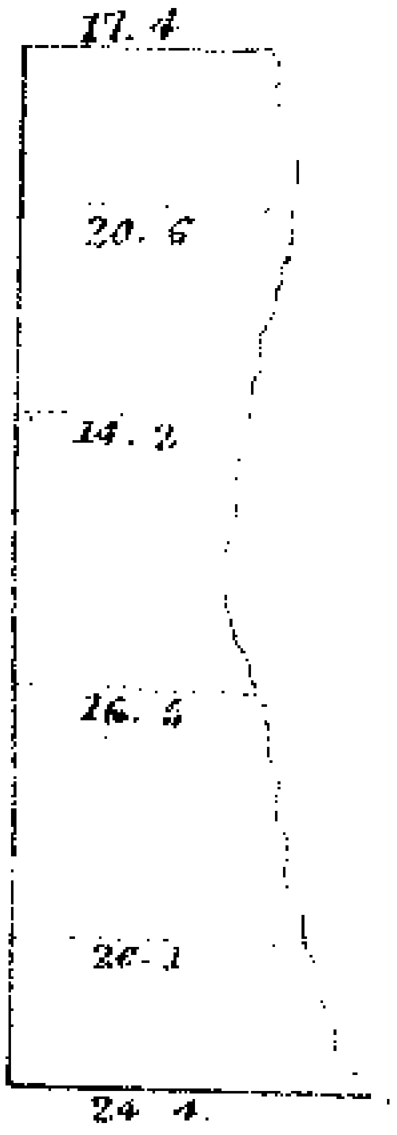
To measure long irregular Figures.

Rule.—Take the breadth in several places at equal distances, add the first and last together, and then divide this sum of the breadths by 2 for the half sum or arithmetical mean between those two; then add together this mean and all the other breadths, omitting the first and last, and divide the sum by the number of parts so added, which will give a medium breadth among the whole; then multiply it by the length, to give the true **Area.** If the breadths be not taken at equal distances, then compute all the little trapezoids separately, and add them all together; or, add all the breadths together, and divide the sum by the whole number of them for the mean breadth to multiply by the length for the whole Area, which will not be far from the truth.

Examples.

(1*st.*) The length of an irregular figure being 84, and the breadths at 6 equi-distant places, 17·4, 20·6, 14·2, 16·5, 20·1, 24·4, what is the area?

17·4
24·4
2|41·8
20·9
20·6
14·2
16·5
20·1
5|92·3
18·46
84
7384
14768
1550·64 *Answer.*



MENSURATION OF SOLIDS.

PROBLEM I.

*To find the Solidity of a Cube.**

Rule.—Cube one of its sides for the contents; that is, multiply the side by itself, and that product by the side again.

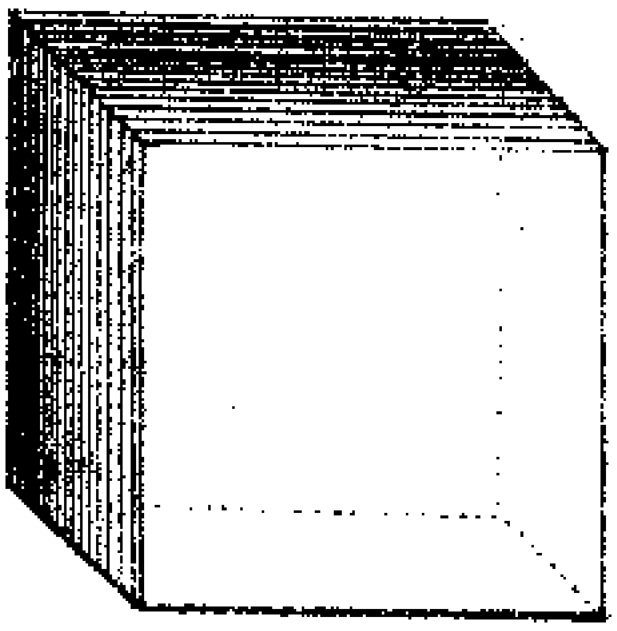
EXAMPLES.

(1*st.*) How many solid feet are there in the cube whose side is 18 inches?

By Duodecimals.	*By Decimals.*
1 - 6	1·5
1 - 6	1·5
1 - 6	7·5
0 - 9	15
2 - 3	225
1 - 6	1·5
2 - 3	1125
1 - 1 - 6	225
3 - 4 - 6 *Answer.*	3·375 = 3⅜ *Answer.*

(2*nd.*) How many solid feet are in the cube whose side is 22 feet?

22
22
44
44
484
22
968
968
10648 *solid feet, Answer.*



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* A Cube is a solid body having six sides, which are Squares, the sides perpendicular to one another, and like a die.

PROBLEM II.

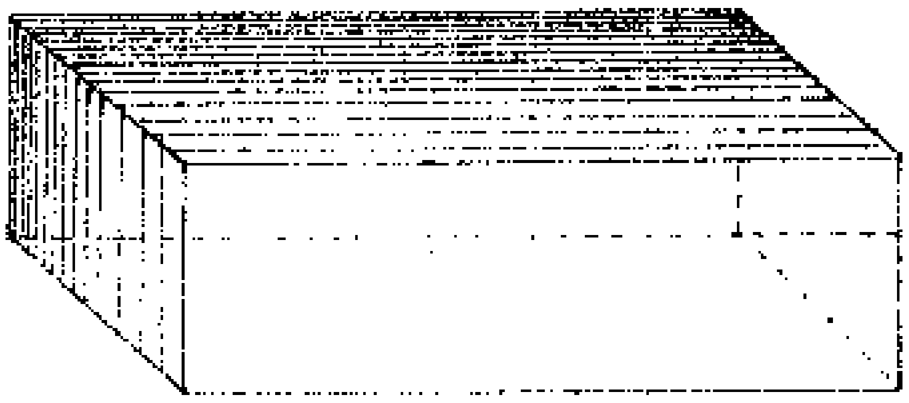
*To find the Solidity of a Parallelopipedon.**

Rule.—Multiply the length, breadth, and depth or altitude, all continually together for the solid contents; that is, multiply the length by the breadth, and that product by the depth.

Examples.

(1*st.*) Required the contents of a parallelopipedon whose length is 10·5, breadth 4·2, and height 3·4.

10·5
4·2
210
420
44·1
3·4
1764
1323
149·94



(2*nd.*) Required the number of cubic feet in a block of marble whose length is 3 feet 2 inches, breadth 2 feet 8 inches, and depth 2 feet 6 inches.

3 - 2
2 - 8
6 - 4
2 - 1 - 4
8 - 5 - 4
2 - 6
16 - 10 - 8
4 - 2 - 8
21 - 1 - 4

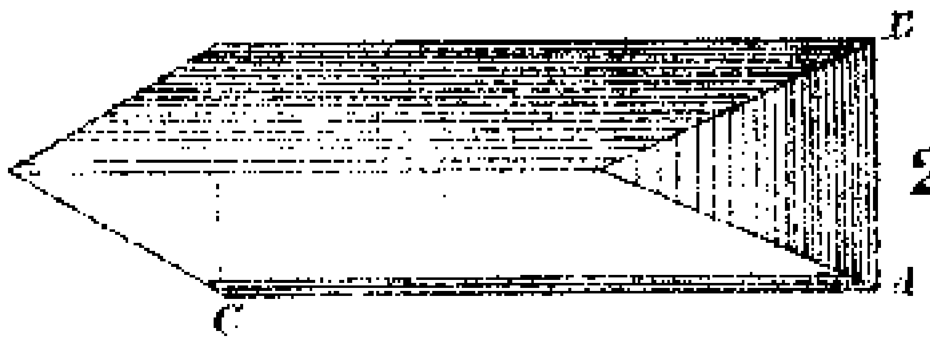
PROBLEM III.

To find the Solidity of any Prism.†

Rule.—Multiply the Area of the base, or end, by the height or length, and it will give the contents,—which rule will do, whether the Prism be triangular, or square, or pentagonal, &c., or round, as a Cylinder.

Examples.

(1*st.*) Required the solidity of a triangular prism whose length is 10 feet, and the three sides of its triangular end, or base, are 5, 4, 3 feet.



4
3
2|12
6 = *area of the triangle ;*
10
60 *Answer.*

---

* A Parallelopipedon is a solid, having six rectangular sides—every opposite pair of which are equal and parallel.

† A Prism is a solid whose ends are any plane figures which are parallel, equal, and similar, and its sides are Parallelograms.

(2*nd.*) What is the contents of a hexagonal prism, the length being 8 feet, and each side of its end 1 foot 6 inches?

1·5
1·5
75
15
2·25
2·598076 (*by Prob. VII.* Mens. Superf.)
12990380
5196152
5196152
5·8456710
8
46·765368 *Answer.*

(3*rd.*) Required the contents of a cylinder whose length is 20 feet and circumference $5\frac{1}{2}$ feet.

By Problem X.
$5{\cdot}5^2 = 30{\cdot}25$
·07958
24200
15125
27225
21175
2·407295
2
4·81459 *Answer.*

(4*th.*) What is the contents of a round pillar whose height is 16 feet, and diameter 2 feet 3 inches?

By Problem X.
$2{\cdot}25^2 = 5{\cdot}0625$
·7854
20·2500
253125
405000
354375
3·9760875
16
63·617400 *Answer.*

PROBLEM IV.

*To find the convex Surface of a Cylinder.**

Rule.—Multiply the circumference by the height or length of the Cylinder.

Note.—The upright surface of any Prism is found in the same manner, *viz.*, by multiplying the Perimeter of the end by the length; and the solidity of a Cylinder is found as the Prism in the last problem.

Examples.

(1*st.*) Required the convex surface of a cylinder whose length is 20 feet and its diameter 2 feet.

(First by Problem VIII. Mens. Superf.*)*

As 1 : 3·1416 : : 2

2

6·2832

20

125·6640 *Answer.*

(2*nd.*) What is the convex surface of the cylinder whose length is 18 feet 6 inches, and circumference 5 feet 4 inches?

By Duodecimals.

18 - 6

5 - 4

92 - 6

6 - 2

98 - 8 *Answer.*

[*Vide Fig.* Prob. III. Example IV.]

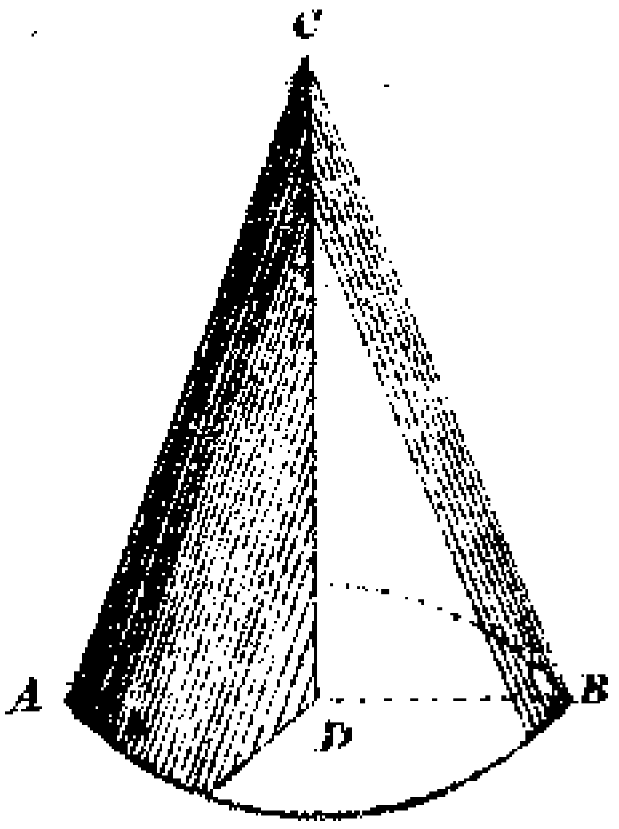
PROBLEM V.

To find the convex Surface of a right Cone.†

Rule.—Multiply the circumference of the Base by the slant height or length of the side, and take half the product for the surface.

Examples.

(1*st.*) What is the convex surface of a cone whose side is 20 and the circumference of its base 9?



9 × 20 = 180 ÷ 2 = 90, *Answer.*

---

* A Cylinder is a round Prism having Circles for its ends.

† A Cone is a round Pyramid having a circular Base.

(2*nd.*) Required the convex surface of a cone whose slant height is 50 feet and the diameter of its base 8 feet 6 inches.

First by Problem VIII. Mensuration Superf.)

```
1 : 3·1416 : : 8·5
          8·5
      -------
       157080
      251328
     --------
     26·70300
           50
    ---------
   2|1335·15
    ---------
      667·575, Answer.
```

PROBLEM VI.

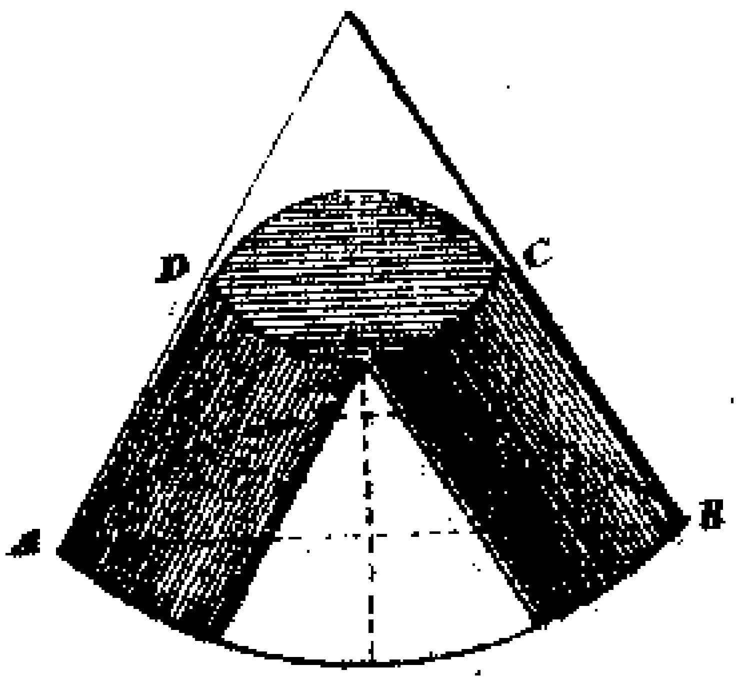
To find the convex Surface of the Frustum of a Right Cone.*

Rule.—Add together the Perimeters of the two ends, then multiply that sum by the slant height, or side of the Frustum, and take half the product for the Surface.

Examples.

(1*st.*) What is the convex surface of the frustum of a cone, the slant height of the frustum being 12·5, and the circumference of the two ends 6 and 8·4?

```
     6
    8·4
   ----
   14·4
   12·5
   ----
    720
  1728
  -----
 2|180·0
  -----
   90·  Answer.
```



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* A Frustum, or trunk, is the part that remains at the bottom after the Segment is cut off.

(2*nd.*) Required the convex surface of the frustum of a cone, the side of the frustum being 10 feet 6 inches, and the circumference of the two ends 2 feet 3 inches and 5 feet 4 inches.

By Duodecimals.	Or, *by Decimals.*
2 - 3	2·25
5 - 4	5·33
7 - 7	7·58
10 - 6	10·5
75 - 10	3790
3 - 9 - 6	7580
2|79 - 7 - 6	2|79·59
39 - 9 - 9 *Answer.*	39·795 *Answer.*

PROBLEM VII.

To find the Solidity of a Cone or any Pyramid.[*]

Rule.—Compute the Area of the Base, then multiply that Area by the height, and take ⅓rd of the product for the contents.

Examples.

(1*st.*) What is the contents of a cone, its height being 10½ feet, and the circumference of its base 9 feet ?

(*By Problem X.* Mens. Superficies.)

$9^2 = 81$
·07958 (*See fig. to Prob. V.*)
·07958
63664
6·44598 *area of the base ;*
10·5
3222990
644598
3|67·682790
22·56093 *Answer.*

---

[*] A Pyramid is a solid having any plane figure for a Base, and its sides are Triangles whose Vertices meet in a point at the top, called the Vertex of the Pyramid.

(2*nd.*) Required the contents of a triangular pyramid, its height being 14 feet 6 inches, and the three sides of its base 5, 6, 7.

5
6
7
2|18
9 — 5 = 4
9 — 6 = 3
9 — 7 = 2

then, 9
4
36
3
108
2
$216^{\frac{1}{2}}$ = 14·696938 *area ;*
14·5
73484692
58787754
14696938
2|213·1056032
71·0352010 *Answer.*

(3*rd.*) What is the contents of a hexagonal pyramid whose height is 6·4, and each side of its base 6 inches?

(*By Prob. VII.* Mens. Superf.) $\overset{in.}{6^2}$ = 1 *foot.*

2·5980762 *area of hex.;*
6·4
103923048
155884572
12|16·62768768
1·38564064 *Answer.*

Or, 6^2 = 36 2·5980762
36
155884572
77942286
93·5307432
6·4
3741229728
5611844592
3|59859675648
1·9953225216 *F., Answer.*

PROBLEM VIII.

To find the Solidity of the Frustum of a Cone or any Pyramid.

RULES.

I.—Add into one sum the Areas of the two ends and the mean proportional between them, or the Square-root of their product, and take $\frac{1}{3}$ of that sum for a mean Area, which multiplied by the height of the Frustum will give the contents.

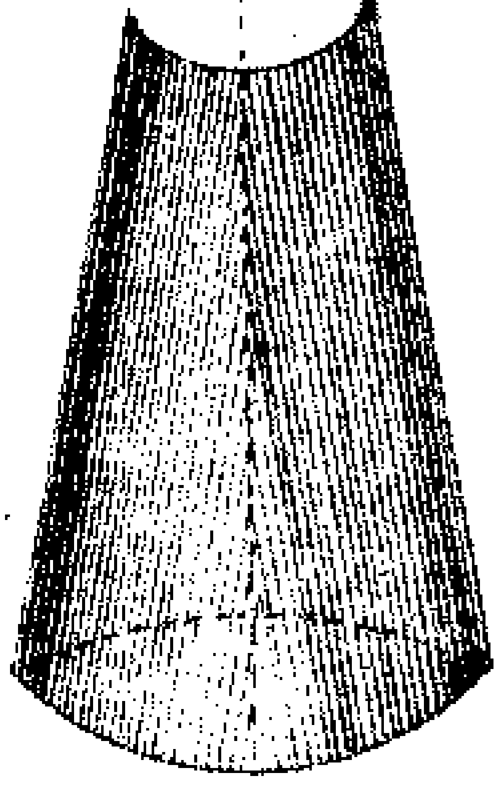
II.—When the ends are regular plane figures, the mean Area will be found by multiplying $\frac{1}{3}$ of the corresponding tabular number belonging to the Polygon, either by the sum arising by adding together the Square of a side of each end and the product of the two sides, or by the Quotient of the Difference of their Cubes divided by their Difference, or by the sum arising from the Square of their half Difference added to 3 times the Square of their half sum.

III.—And in the Frustum of a Cone, the mean Area is found by multiplying ·2618, or $\frac{1}{3}$ of ·7854, either by the sum arising by adding together the Squares of the two Diameters and the product of the two, or by the Difference of their Cubes divided by their Difference, or by the Square of half their Difference added to 3 times the Square of their half sum; or, if the Circumferences be used in like manner instead of their Diameters, the Multiplier will be ·02654 instead of ·2618.

EXAMPLES.

(1*st.*) What is the solidity of the frustum of a cone, the altitude being 25, the circumference at the greater end 20, and at the less end 10?

$20^2 = 400$ *square of circumference at the base;*
$10^2 = 100$ *ditto ditto upper end;*
$10 \times 20 = 200$ *product of both circumferences;*
700
·07958
3|55·706
18·568$\frac{2}{3}$
25
92840
37136
16
464·216 *Answer.*



(*2nd.*) How many solid feet are in a piece of timber whose bases are squares, each side of the greater end being 15 inches, and each side of the less end 6 inches, also the length or perpendicular altitude 24 feet?

15
15
225 *area of the greater* □
36
1350
675
8100 = $\sqrt{90}$ = *mean area;*

261 *area of the squares;*
90
3|351
117
in. 288 = *height of frustum;*
936
936
234
1728|33696| ·19·5 *cubic feet;*
16316
8640

(*3rd.*) To find the contents of the frustum of a cone, the altitude being 18, the greatest diameter 8, and the least 4.

8^2 = 64
4^2 = 16
80 = *square of diameters;*
4 × 8 = 32 = *product of ditto;*
112
2618
31416
2618
29·3216
18 *height;*
2345728
29·3216
527·7888 *Answer.*

(*4th.*) What is the solidity of a hexagonal frustum, the height being 6 feet, the side of the greater end 18 inches, and of the less 12 inches?

4·75
·8660254
43301270
60621778
34641016
4·113620650
6
24·6817239 *Answer.*

PROBLEM IX.

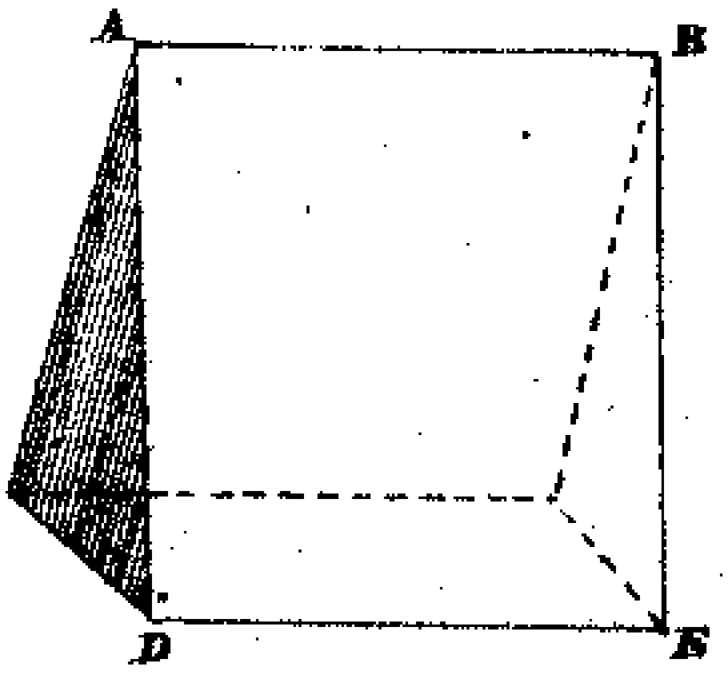
To find the Solidity of a Wedge.

Rule.—To the length of the edge add twice the length of the back or base, and reverse the sum, multiply the height of the wedge by the breadth of the base, then multiply this product by the reversed sum, and take ⅙ of the last product for the contents.

Examples.

(1*st.*) Required the contents of a wedge, the length and breadth of the base being 70 and 30 inches, the length of the edge 110 inches, and the height 34 29016.

34·29016
30
102·87048
250
51435240
20574096
625717·62
1728| 4286·27 *cubic inches ;*
24·8048 *cubic feet, Answer.*



PROBLEM X.

To find the convex Surface of a Sphere or Globe.

Rule.—Multiply its Circumference by its Diameter.

Note.—In like manner the convex Surface of any Zone or Segment is found by multiplying its height by the whole Circumference of the Sphere.

Examples.

(1*st*) What is the convex surface of a sphere whose diameter is 7, and the circumference 22?

22
7
154 *Answer.*

(2*nd*) Required the area of the surface of the Earth, its diameter or axis being 7957¾ miles, and its circumference 25,000 miles.

7957·75
25000
3978875000
1591550
19894375· *Answer.*

(*3rd.*) The axis of a sphere being 42 inches, what is the convex superficies of the segment whose height is 9 inches?

7 : 22 : : 42
22
84
84
7|924
132
9
1188 *Answer.*

(*4th.*) Required the convex surface of a spherical zone whose breadth or height is 2 feet, and cut from a sphere of 12½ feet diameter.

7 : 22 : : 12·5
22
250
250
7|275
39·285
2
78·57 *Answer.*

* * *

PROBLEM XI.

To find the Solidity of a Sphere or Globe.

Rule.—Find the Cube of the Axis, and multiply it by ·5236.

Example.

(*1st.*) To find the contents of the sphere whose axis is 2 feet 8 inches.

2·666666
2·666666
15999996
15999996
15999996
15999996
15999996
15999996
5333332
7·111107555556
2·666666
42666645333336
42666645333336
42666645333336
42666645333336
42666645333336
42666645333336
14222215111112
18·962948730744296296 × ·5236 = 9·9289 feet, *Answer.*

* * *

PROBLEM XII.

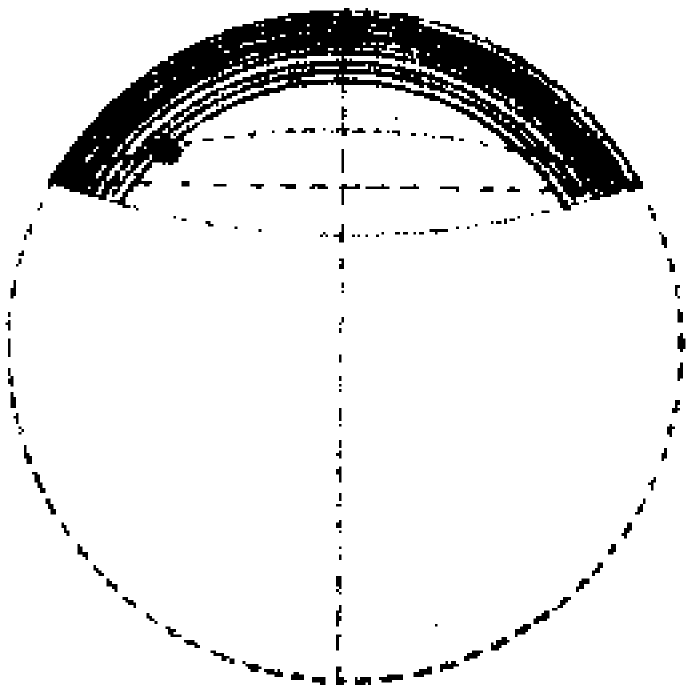
To find the Solidity of a Spherical Segment.

Rule.—To three times the Square of the Radius of its [illegible]se add the Square of its Height; then multiply the sum [illegible] the said Height, and the product again by ·5236.

Examples.

(1*st.*) What is the solidity of the segment of a sphere whose height is 9 and the diameter of its base 20?

10^2 = 100
3
300 = 3 *times the square of the radius;*
92 = 381 = *square of height;*
9 = *height;*
3429
·5236 = tab. number;
20574
10287
6858
17145
1795·4244 *Answer.*



(2*nd.*) Required the contents of the spherical segment whose height is $2\frac{1}{4}$, and the diameter of its base 8·61684.

4·30842 = *radius;*
4·30842
861684
1723368
3446736
1292526
1723368
18·5624828564 = ^{2} *radius;*
3
55·6874485692 = 3^2 *radius;*
5 0625 = *square of height;*
60·7499485692
2·25 = *height;*
3037497428460
1214998971384
1214998971384
136·6873842807

136·6873842807
·5236
8201243056842
4100621528421
2733747685614
6834369214035
71·5695144093 7152 *Ans.*

PROBLEM XIII.

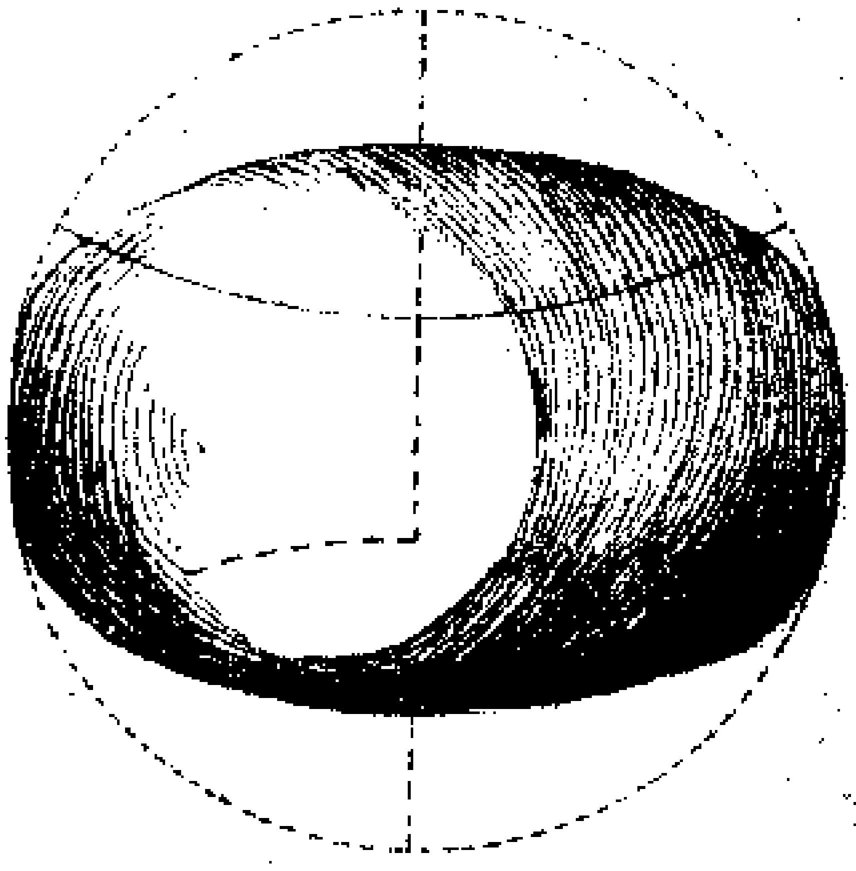
To find the Solidity of a Spherical Zone or Frustum.

Rule.—Add together the Square of the Radius of each end and $\frac{1}{3}$ of the Square of their Distance, or of the Height; then multiply the sum by the said Height, and the product again by 1·5708.

Examples.

(1*st.*) Required the contents of a zone whose greater diameter is 12, less diameter 10, and height 2.

$$\begin{array}{rcrl}
6^2 & = & 36 & = (\textit{radius of greater end})^2 \\
5^2 & = & 25 & = (\textit{radius of less end})^2 \\
\frac{1}{3} \text{ of } 2^2 & = & 1\frac{1}{3} & = \frac{1}{3} \textit{ of altitude;} \\
 & & \overline{62\frac{1}{3}} & \\
 & & 2 & = \textit{altitude;} \\
 & & \overline{124\frac{2}{3}} & = \frac{374}{3}; \\
\text{hence,} & & 1{\cdot}5708 & \\
 & & 374 & \\
 & & \overline{62832} & \\
 & & 109956 & \\
 & & 47124 & \\
 & & 3\,|\overline{587{\cdot}4792} & \\
 & & \overline{195{\cdot}8264} & \textit{Answer.}
\end{array}$$



(2*nd.*) What is the contents of a middle zone, whose height is 8 feet and the diameter of each end 6?

$$\begin{array}{rcrl}
3^2 & = & 9 & \\
3^2 & = & 9 & = (\textit{radii of both ends})^2 \\
\frac{1}{3} \text{ of } 8^2 & = & 21\frac{1}{3} & = \frac{1}{3}\ (\textit{of altitude})^2 \\
 & & \overline{39\frac{1}{3}} & \\
 & & 8 & = \textit{altitude;} \\
 & & \overline{312\frac{8}{3}} & = \frac{944}{3} \\
\text{hence,} & & 1{\cdot}5708 & \\
 & & 944 & \\
 & & \overline{62832} & \\
 & & 62832 & \\
 & & 141372 & \\
 & & 3\,|\overline{1482{\cdot}8352} & \\
 & & \overline{494{\cdot}2784} & \textit{Answer.}
\end{array}$$

PROBLEM XIV.

To find the Surface of a Circular Spindle.

Rule.—Multiply the Length, *AB*, of the Spindle by the Radius, *OC*, of the revolving Arc; multiply also the said Arc, *ACB*, by the central Distance *OE*, or Distance between the centre of Spindle and centre of the revolving Arc; subtract the latter product from the former, and multiply double the Remainder by 3·1416, or the single Remainder by 6·2832 for the Surface.

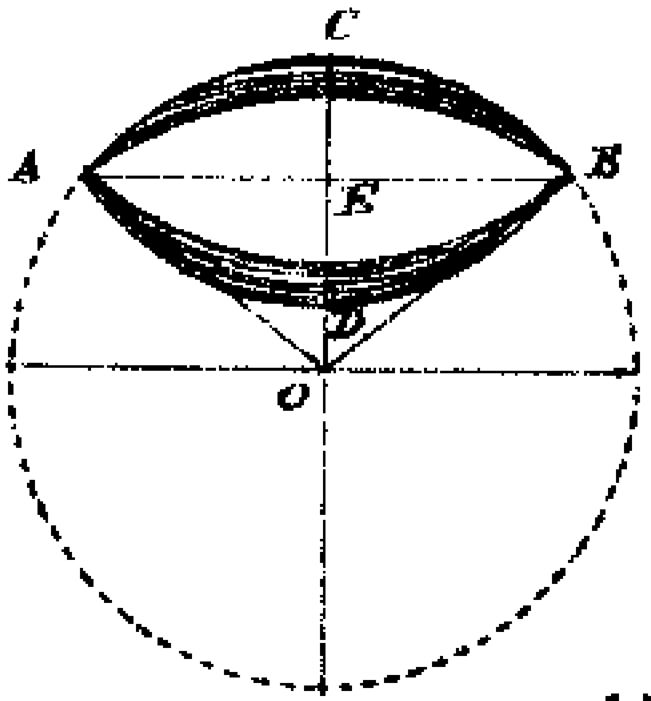
Note.—The same Rule will serve for any Segment or Zone cut off perpendicular to the Chord of the revolving Arc, only using the particular length of the part and the part of the Arc which describes it, instead of the whole length and whole Arc.

Example.

What is the surface of a circular spindle whose length is 24, and thickness in the middle 18?

$$AE = 12^2 = 144$$
$$EC = 92 = 81$$
$$\sqrt{225} = 15 = AC$$

$$CO = \frac{AC^2}{CD^2} = \frac{15^2}{18} = 225 \div 18 = 12\cdot5 = CO;$$



then, 24 = *AB*
12 5 = *CO*
500
250
300
112
188
6·2832
502656
502656
62832
1181·2416 *Answer.*

15 = *half arc;*
8
120
24 = *chord of whole arc;*
3|96
32 = *ACB*
3·5 = *OE*
70
105
112

PROBLEM XV.

To find the Solidity of a circular Spindle.

Rule.—Multiply the central Distance, *OE*, by half the Area of the revolving Segment *ACBEA;* subtract the product from $\frac{1}{3}$rd of the Cube of *AE* half the length of the Spindle; then multiply the Remainder by 12·5664, or 4 times 3·1416 for the whole contents.

Example.

What is the solidity of a circular spindle whose length is 24 and middle diameter 18?

Here, by the Example in the preceding problem, we have the Arc $ACB = 32$; hence the Arc $AC = 16$; also CO, or the Radius, $= 12{\cdot}5$, and $OE = 3{\cdot}5$.

Then, (*by Problem XII.,*—Mensuration Superf.;)

$$AC \times OC = 16 \times 12{\cdot}5 = 200 = \textit{area of sector;}$$

$$\frac{AB \times OE}{2} = \frac{24 \times 3{\cdot}5}{2} = 42 = \textit{area of triangle;}$$

$$158 = \textit{area of segment;}$$

Now, (*by the Rule;*)

$$\begin{array}{rl} OE = 3{\cdot}5 & \\ \underline{79} = \textit{half the area of the segment;} & \\ 395 & \\ \underline{237} & \\ 276{\cdot}5 & 3\,|\,\underline{1728} \\ & 576 = \frac{1}{3} \textit{ the cube of } AE; \\ & \underline{276{\cdot}5} \\ & 299{\cdot}5 \\ & \underline{12{\cdot}5664} \\ & 628320 \\ & 1130976 \\ & 1130976 \\ & \underline{251328} \\ & 3763{\cdot}6368 \textit{ Answer.} \end{array}$$

Or, $\frac{9}{25} = {}$·36 = *height of segment ;*

then, ·25455 corresponding tab. number

$$\begin{array}{r}
625 \\ \hline
127275 \\
50910 \\
152730 \\ \hline
159{\cdot}09375
\end{array}
\qquad
\begin{array}{r}
159{\cdot}09375 = ACBEA\,; \\
3{\cdot}5 \\ \hline
79546875 \\
47728125 \\ \hline
2|556{\cdot}828125 \\ \hline
278{\cdot}4140625
\end{array}$$

$$\begin{array}{r}
576 = \tfrac{1}{3} \textit{ of the cube of } AE\,; \\
278{\cdot}4140625\phantom{\textit{ of the cube of } AE\,;} \\ \hline
297{\cdot}5859375\phantom{\textit{ of the cube of } AE\,;} \\
12{\cdot}5664\phantom{\textit{ of the cube of } AE\,;} \\ \hline
11903437500\phantom{\textit{ of the cube of } AE\,;} \\
17855156250\phantom{0\textit{ of the cube of } AE\,;} \\
17855156250\phantom{00\textit{ of the cube of } AE\,;} \\
14879296875\phantom{000\textit{ of the cube of } AE\,;} \\
5951718750\phantom{0000\textit{ of the cube of } AE\,;} \\
2975859375\phantom{00000\textit{ of the cube of } AE\,;} \\ \hline
3739{\cdot}583925 \textit{ Answer.}\phantom{00000\textit{ of the cube of } AE\,;}
\end{array}$$

PROBLEM XVI.

To find the Solidity of the middle Frustum or Zone of a circular Spindle.

Rule.—From the Square of half the length of the whole Spindle, take ⅓rd of the Square of half the length of the middle Frustum, and multiply the Remainder by the said half length of the middle Frustum. Multiply the central distance by the revolving Area which generates the middle Frustum; subtract this latter product from the former, then the Remainder multiplied by 6·2832, or twice 3·1416, will give the contents.

Example.

What is the contents of the middle frustum of a circular spindle whose length is 20, greater diameter 18, and least diameter 8?

Here, $DG = \frac{1}{2}\,MN = \frac{20}{2} = 10 =$ half the length of the middle frustum.

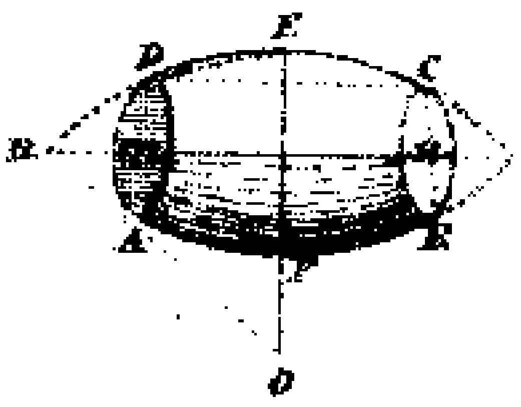
$EG = \frac{1}{2}\,EF - \frac{1}{2}\,AD = \frac{18}{2} - \frac{8}{2} = 5$, versed sine of segment; and diameter of generating circle $= DG^2 + EG^2 = \frac{100}{5} \times 25 = \frac{125}{5} = 25$; the radius $= 12{\cdot}5 = OH$ or OE.

Also $EGOI = OE - EI = 12{\cdot}5 - 9 = 3{\cdot}5 = OI =$ central distance;

(*Problem II.*) $12{\cdot}5^2 = 156{\cdot}25 = HO$;
$35^2 = 12{\cdot}25 = OI$;
$144{\cdot} = HI^2$;

(*Problem XII.*) $\frac{5}{25} = {\cdot}2 = 111823 =$ corresponding tab. number;
625 = *square of diameter;*
559115   144 *do. half length of whole spindle;*
223646 $33\frac{1}{3} = \frac{1}{3}$ *of the square of MI;*
670938 $110\frac{2}{3}$
69·889375   10

Area of $DMNC = 80$ 1106·6666666
149·889375   524·6128125
3·5   582·0538541
749446875   6·2832
449668125   11641077082
524·6128125   17461615623
46564308328
11641077082
34923231246
3657·16077608112 *Answer.*



PROBLEM XVII.

To find the Superficies or Solidity of any regular Body.

RULE I.—Multiply the proper tabular Area (taken from the following table), by the Square of the linear edge of the Solid, for the Superficies.

II.—Multiply the tabular Solidity by the Cube of the linear edge for the Solid contents.

SURFACES AND SOLIDITIES OF REGULAR BODIES.

Number of Faces.	Names.	Surfaces.	Solidities.
4	*Tetrahedron,*	1·73205	0·11785
6	*Hexahedron,*	6·00000	1·00000
8	*Octahedron,*	3·46410	0·47140
12	*Dodecahedron,*	20·64573	7·66312
20	*Icosahedron,*	8·66025	2·18169

EXAMPLES.

(1*st.*) What are the superficies and solidity of the hexahedron whose lineal side is 2.

$2^2 = 4 =$ *square of the lineal edge of the solid;*
$6 =$ tab. number;
$\overline{24}$ *superficies, Answer.*
$\overline{2^3} = 8 =$ *cube of lineal edge;*
$1 =$ tab. number;
$\overline{8}$ *solidity, Answer.*

(2*nd.*) Required the superficies and solidity of the octahedron whose lineal side is 2?

$2^2 = 4$
$3{\cdot}4641 =$ tab. number;
$\overline{13{\cdot}8564}$ *superficies; Answer.*

$2^3 = 8$
$\cdot4714 =$ tab. number;
$\overline{3{\cdot}77120}$ *solidity, Answer.*

(3*rd.*) Required the superficies and solidity of the dodecahedron whose lineal side is 2?

$2^2 = 4 =$ *square of the lineal edge of the solid;*
$20{\cdot}64573 =$ tab. number;
$\overline{82{\cdot}58292}$ *superficies, Answer.*

$2^3 = 8$
$7{\cdot}66312 =$ tab. number;
$\overline{61{\cdot}30496}$ *solidity, Ans.*

(4*th.*) What are the superficies and solidity of the icosahedron, whose lineal side is 2?

$2^2 = 4$
$8{\cdot}66025$ tab. number;
$\overline{34{\cdot}64100}$ *superficies, Answer.*

$2^3 = 8$
$2{\cdot}18169$
$\overline{17{\cdot}45352}$, *solidity, Ans.*

* * *

PROBLEM XVIII.

To find the Surface of a cylindrical Ring.

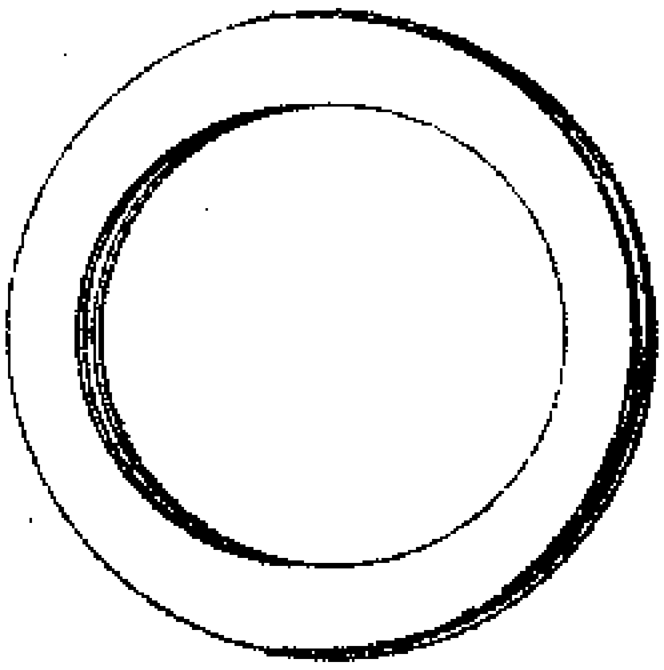
RULE.—This figure being only a Cylinder bent round into a ring, its Surface and Solidity may be found as in the Cylinder, namely, by multiplying the Axis, or length of the Cylinder, by the Circumference of the Ring, or of the Section for the Surface, and by the Area of a Section for the Solidity.

Or use the following Rule for the Surface.—To the thickness of the Ring add the inner Diameter; multiply this sum by the thickness and the product again by 9·8696, or the Square of 3·1416.

EXAMPLE.

What is the surface of a ring whose inner diameter is 16, and thickness 4?

4 = *thickness;*
16 = *inner diameter;*
20
4
80
9·8696 = tab. number;
789·568 *Answer.*



PROBLEM XIX

To find the Solidity of a cylindrical Ring.

RULE.—To the thickness of the Ring add the inner Diameter; then multiply that sum by the Square of the thickness, and the product again by 2·4674, or ¼ of the Square of 3·1416 for the Solidity.

EXAMPLE.

What is the solidity of a cylindrical ring whose thickness is 4, and inner diameter 16?

4 *thickness;*
16 *inner diameter;*
20
16 = *square of thickness;*
320
2·4674 = tab. number;
493480
74022
789·5680 *Answer.*

TIMBER MEASURING.

PROBLEM I.

To find the Area or Superficial Contents of a Board or Plank.

Rule.—Multiply the length by the mean breadth.

Note.—When the board is tapering, add the breadths at the two ends together, and take half the sum for the mean breadth.

Examples.

(1*st.*) Required the contents of a board whose length is 11 feet 2 inches, and breadth 1 foot 10 inches.

By Duodecimals.

11 - 2 = *length ;*
1 - 10 *breadth ;*
11 - 2
9 - 3 - 8
20 - 5 - 8 *Answer.*

By Decimals (Repetends.)

$11{\cdot}1\dot{6}$
$1{\cdot}83$
9|33 50
3722
89333
111666
$20{\cdot}472$

(2*nd.*) What is the value of a plank which is 12 feet 9 inches long, and 1 foot 3 inches broad, at $2\frac{1}{2}d.$ a foot?

12 - 9
1 - 3
12 - 9
3 - 2 - 3
15 - 11 - 3
$2\ \frac{1}{6}$ | 2 - 7 - 10
$\frac{1}{2}\ \frac{1}{4}$ | 0 - 7 - 11
3 - 3 - 9 *Answer.*

Or, $12{\cdot}75$
$1{\cdot}25$
6375
2550
1275
$15{\cdot}9375$
$2\frac{1}{6}$ | $2{\cdot}65625$
$2\frac{1}{4}$ | 0 6640625
$3{\cdot}3203125$ 3*s.* $3\frac{3}{4}$*d.*, *Answer.*

(3*rd.*) Required the value of 5 oaken planks at 3*d.* per foot, each of them being 17½ feet long, and their several breadths are as follow, namely, 2 of 13½ inches in the middle, 1 of 14¼ inches in the middle, and the 2 remaining ones, each 18 inches at the broader end, and 11¼ at the narrower.

$$\begin{array}{lr}
2 \textit{ of } 13\tfrac{1}{2} = & 2{\cdot}25 \\
1 \textit{ of } 14\tfrac{1}{4} = & 1{\cdot}1875 \\
2 \textit{ of } 18 + 11, & 2{\cdot}4375 \\ \hline
 & 5{\cdot}875 \\
 & 17\ 5 \\ \hline
 & 29375 \\
 & 41125 \\
 & 5875 \\ \hline
 & 1028125 \\
 & {\cdot}0125\ \text{£, } \textit{or } 3d. \\ \hline
 & 5140625 \\
 & 2056250 \\
 & 1028125 \\ \hline
 & 1{\cdot}28515625 \\
 & 20 \\ \hline
 & 5{\cdot}703125 \\
 & 12 \\ \hline
 & 8\ 4375 \\
 & 4 \\ \hline
 & 1{\cdot}75
\end{array}$$

$$\begin{array}{rl}
 & \textit{ft.}\quad \textit{in.} \\
\text{Or, } 2 \textit{ of } 13\tfrac{1}{2} = & 2 - 3 \\
1 \textit{ of } 14\tfrac{1}{4} = & 1 - 2 - 3 \\
2 \textit{ of } 18 + 11\tfrac{1}{4} = & 2 - 5 - 3 \\ \hline
 & 5 - 10 - 6 \\
 & 17 - 6 = \textit{length}; \\ \hline
 & 102 - 9 - 9 \\
 & \text{£}\quad s.\quad d. \\
 & 3 \\
 & 10 \times 10 + 2 = 102 \\ \hline
 & 0 - 2 - 6 \\
 & 10 \\ \hline
 & 1 - 5 - 0 = 100 \\
6 = \tfrac{1}{4} & 6 = 2 \\
3 = \tfrac{1}{2} & 1\tfrac{1}{2} = 0 - 6 \\
9 = \tfrac{1}{4} & \tfrac{3}{4} = 0 - 3 \\
 & 0 \quad \tfrac{3}{4} - 0 - 9 \\ \hline
 & 1 - 5 - 8\tfrac{1}{4} = 102 - 9 - 9
\end{array}$$

£ 1 5*s.* 8¼*d.*, *Answer.*

PROBLEM II.

To find the Solid Contents of a squared or four-sided Timber.

Rule.—Multiply the mean breadth by the mean thickness, and the product again by the length, and the last product will give the contents.

EXAMPLES.

(1*st.*) What is the contents of the piece of timber whose length is $24\frac{1}{2}$ feet, and the mean breadth and thickness each 1·04 feet?

1·04 *mean breadth ;*
1·04 *mean thickness ;*
416
104
1·0816
24·5 *length ;*
54080
43264
21632
26·4992 *Answer.*

(2*nd.*) Required the contents of a piece of timber whose length is 20·38 feet, and its ends unequal squares, the side of the greater being $19\frac{1}{8}$, and the side of the less $9\frac{7}{8}$ inches.

19·125
9·875
12|29
2|2·4166
1·2083

1·2083 = *mean breadth ;*
1·2083 = *mean thickness :*
9|36250
40277
966666
24166666
120833333
·14600694
20·38 *length ;*
116805555
438020833
2920138888
29·75621527 *Answer.*

(3*rd.*) Required the contents of a piece of timber whose length is 27·36 feet at the greater end, the breadth is 1·78, and the thickness 1·23, and at the less end the breadth is 1·04 and thickness 0·9?

1·04
1·78
2|2·82
1·41 *mean breadth ;*

1·41
1·07
987
141
1·5087

1·5087
27·36 *length ;*
90522
45261
105609
30174
41·278032, *Answer.*

PROBLEM III.

To find the Solidity of round or unsquared Timber.

Rule I., *or* Common Rule.—Multiply the Square of the quarter girth, or ¼th of the mean Circumference, by the Length for the contents.

EXAMPLES.

(1*st.*) What is the contents of a tree whose mean girth is 3·15 feet, and length 14 feet 6 inches?

$$\begin{array}{rl}
4\,|\,3{\cdot}15 & \\
\hline
0{\cdot}7875 & = \textit{quarter girth;} \\
{\cdot}7875 & \\
\hline
39375 & \\
55125 & \\
63000 & \\
55125 & \\
\hline
{\cdot}62015625 & \textit{square of quarter girth;} \\
14{\cdot}5 & \textit{length;} \\
\hline
310078125 & \\
248062500 & \\
62015625 & \\
\hline
8\ 992265625 & \textit{Answer.}
\end{array}$$

(2*nd.*) Required the contents of a tree whose length is 17¼ feet, which girths in 5 different places as follows, namely, in the first place 9·43 feet; in the second, 7·92; in the third, 6·15; in the fourth 4·74, and in the fifth, 3·16.

$$\begin{array}{rl}
9{\cdot}43 & \\
7{\cdot}92 & \\
6{\cdot}15 & \\
4{\cdot}74 & \\
3{\cdot}16 & \\
\hline
5\,|\,31{\cdot}40 & \\
\hline
4\,|\,6{\cdot}28 & \textit{mean girth;} \\
\hline
1{\cdot}57 & \\
1{\cdot}57 & \\
\hline
2{\cdot}4649 &
\end{array}
\qquad\qquad
\begin{array}{rl}
2{\cdot}4649 & \\
17\tfrac{1}{4} & \\
\hline
172543 & \\
24649 & \\
6162 & \\
\hline
42{\cdot}5195 & \textit{Answer.}
\end{array}$$

Note.—When the tree is very irregular, add all the girths together, and divide the sum by the number of them for the mean girth then proceed by the Rule.

Rule II.—Multiply the Square of ⅕th of the mean girth by double the length, and the product will be the contents, very near the truth.

EXAMPLES.

(1*st.*) Required the contents of a tree which is 24 feet long, and mean girth 8 feet.

5|8
1·6
1·6
2·56
48 *double the length ;*
2048
1024
122·88 *Answer.*

(2*nd.*) The length of a tree is 14½ feet, and mean girth 3·15 feet, what is the contents ?

5|3·15
·63
·63
189
378
3969 = $\frac{1}{5}$ *square of mean girth ;*
29
35721
7938
11·5101 *Answer.*

(3*rd.*) The length of a tree is 17¼ feet, and its mean girth 6·28, what is the contents ?

5|6·28
1·256
1·256
7536
6280
2512
1256
1·577536
34·5 = *double the length ;*
7887680
6310144
4733608
54·4349920 *Answer.*

MASONS' WORK.

To Masonry belongs all sorts of Stone-work, and the measure made use of is a foot, either Superficial or Solid.

Walls, columns, blocks of stone or marble, &c., are measured by the cubic foot, and pavements, slabs, chimney-pieces, &c., by the superficial or square foot.

Cubic or Solid Measure is used for the materials, and Square Measure for workmanship. In the Solid Measure the true length, breadth, and thickness are taken and multiplied continually together. In the Superficial there must be taken the length and breadth of every part of the projection which is seen without the general upright face of the building.

EXAMPLES.

(1*st.*) What is the solid contents of a wall, the length being 24 feet 3 inches, height 10 feet 9 inches, and 2 feet thick?

24 - 3 *length;*	24·25
10 - 9 *breadth;*	10·75
242 - 6	12125
18 - 2 - 3	16975
260 - 8 - 3	2425
2 *breadth or thickness;*	260·6875
521 - 4 - 6 *ft.;*	2
	521·375 *Answer.*

(2*nd.*) Required the value of a marble slab at 8*s.* per foot, the length being 5 feet 7 inches, and breadth 1 foot 10 inches.

		£ *s.*
	2⅙	- 8
5 - 7		10
1 - 10		4 - 0
5 - 7	8⅓	0 - 1 - 4
4 - 7 - 10	2¼	0 - 5¼
10 - 2 - 10		0 - 1¼
		£4 - 1 - 10½ *Answer.*

In a chimney-piece, suppose the length of the marble and slab—

Each, ...	4 feet 6 inches,
Breadth of both together, ...	3 feet 2 inches,
Length of each jamb, ...	4 feet 4 inches,
Breadth of both together, ...	1 foot 9 inches,

Required the superficial contents.

4 - 4	4 - 6
1 - 9	3 - 2
4 - 4	13 - 6
3 - 3	9
7 - 7	14 - 3
	7 - 7
	21 - 10 *inches, Ans.*

CARPENTERS' AND JOINERS' WORK.

To this branch belongs all the Wood-work of a house, such as Flooring, Partitioning, Roofing, &c.

NOTE.—Large and plain articles are usually measured by the square foot or yard, &c.; but enriched mouldings and some other articles are often estimated by running or lineal measure, and some things are rated by the piece.

In measuring joists it is to be observed that only one of their dimensions is the same with that of the floor, and the other will exceed the length of the room by the thickness of the wall and $\frac{1}{3}$rd of the same, because each end is let into the wall about $\frac{2}{3}$rds of the thickness.

No deductions are made for the hearths, on account of the additional trouble and waste of materials.

Partitions are measured from wall to wall for one dimension, and from floor to floor as far as they extend for the other.

No deduction is made for doorways, on account of the trouble of framing them.

In measuring of Joiners' Work the string is made to ply close to every part of the work over which it passes.

The measure of centering for cellars is found by making a string pass over the surface of the arch for the one dimension, and taking the length of the cellar for the other; but in *groin centering* it is usual to allow double measure on account of their extraordinary trouble.

In Roofing, the length of the house in the inside, together with $\frac{2}{3}$rds of the thickness of one gable, is to be considered as the length, and the breadth is equal to double the length of a string, which is stretched from the ridge down the rafter and along the eaves-board till it meets with the top of the wall.

For Stair-cases, take the breadth of all the steps by making a line ply close over them from the top to the bottom, and multiply the length of this line by the length of a step for the whole Area. By the length of a step is meant the length of the front and the returns at the two ends, and by the breadth is understood the girth of its two outer surfaces, or the tread and rise.

For the Balustrade, take the whole length of the upper part of the hand-rail, and girt over its end till it meets the top of the newel-post for the length, and twice the length of the balustur upon the landing, with the girth of the hand-rail, for the breadth.

For Wainscoating, take the compass of the room for the length, and the height from the floor to the ceiling, and making the string ply close into all the mouldings for the breadth. Out of this must be made deductions for windows, doors, and chimneys, &c., but workmanship is counted for the whole on account of the extraordinary trouble.

For Doors, it is usual to allow for their thickness by adding it into both the dimensions of length and breadth, and then multiply them together for the Area. If the door be panelled on both sides, take double the measure for the workmanship, but if one side only be panelled, take the Area and its half for the workmanship. For the surrounding Architrave gird it about the outermost part for one dimension, and measure over it as far as it can be seen when the door is open for the other.

Window-shutters, bases, &c. are measured in the same manner. In the measuring of Roofing for workmanship alone, the holes for chimney shafts and skylights are generally deducted. But in measuring for work in materials, they commonly measure in all skylights luthern lights and holes for chimney shafts, on account of their trouble and waste of materials.

EXAMPLES.

(1*st.*) A floor being 36 feet 3 inches long, 16 feet 6 inches broad, how many squares are in it?

36 - 3 *length ;*
16 - 6
580 - 0
18 - 1 - 6
100|598 - 1 - 6
5·98 - 1 - 6 *squares, Ans.*

36·25
16·5
18125
21750
3625
100|598·125
5·98125 *squares, Ans.*

(2*nd.*) How many squares are there in 173 feet 10 inches in length, and 10 feet 7 inches height or partitioning?

173 - 10 *length ;*
10 - 7 *breadth ;*
1738 - 4
101 - 4 - 10
100|1839 - 8 - 10
18·39 - 8 - 10 *squares, Answer.*

(3*rd.*) What cost the roofing of a house at 10*s.* 6*d.* a square, the length within the walls being 52 feet 8 inches, and the breadth 30 feet 6 inches, reckoning the roof $\frac{3}{2}$rds of the flat?

ft. *ins.*
52 - 8
30 - 6
1580 - 0
26 - 4
2|1606 - 4 *flat roof ;*
803 - 2
100|2409 - 6$\frac{3}{2}$ *sloped roof ;*
24 *sq.* 9$\frac{1}{2}$ *feet.*

£. *s.* *d.*
0 - 10 - 6
6 × 4
3 - 3 - 0
4
12 - 12 - 0

£. *s.* *d.*
12 - 12 - 11$\frac{3}{4}$ *Answer.*

(*4th.*) To how much, at 6*s.* per square yard, amounts the wainscoating of a room, the height taking in the cornice and mouldings being 12 feet 6 inches, and the whole compass 83 feet 8 inches, also the three window-shutters are each 7 feet 8 inches by 3 feet 6 inches, and the door 7 feet by 3 feet 6 inches, the door and shutters being worked on both sides, and reckoned work and half-work ?

83 - 8 *whole compass ;*
12 - 6
1004 - 0
41 - 10
1045 - 10
52 - 6
9|1098 - 4
122
6
20|732
£36 - 12 *Answer.*
$\frac{1}{27}$ of 6*s.* = ✓ of $\frac{1}{3}$ *foot.*

ft. *ins.*
7 - 8 *window-shutters ;*
3 - 6
23 - 0
3 - 10
26 - 10
3
80 - 6
24 - 6
2|105 - 0
52 - 6

7 - 0
3 - 6
24 - 6 *door ;*

SLATERS' AND TILERS' WORK.

In these articles the contents of a Roof is found by multiplying the length of the ridge by the girth over from eaves to eaves, making allowance in this girth for the double row of slates at the bottom, or for how much one row of slates or tiles is laid over another.

When the Roof is of a true pitch, that is, forming a right angle at top, then the breadth of the building, with its half added, is the girth over both sides.

In angles formed in a Roof running from the ridge to the eaves, when the angle bends inwards, it is called a *valley*, but when outwards it is called a *hip*.

Deductions are made for chimney shafts or window holes.

EXAMPLE.

To how much amounts the tiling of a house at 25*s.* 6*d.* per square, the length being 43 feet 10 inches, and the breadth on the flat 27 feet 5 inches, also the eaves projecting 16 inches on each side, and the roof of a true pitch?

52 - 8
30 - 6
1580 - 0
26 - 4
1606 - 4 *flat roof;*
803 - 2
100|2409 - $6\frac{2}{3}$ *sloped roof;*
24 *sq.*, $9\frac{1}{2}$ *feet, Answer.*

PLASTERERS' WORK.

PLASTERERS' Work is of two kinds, namely, *ceiling*, which is plastering upon laths, and *rendering*, which is plastering upon walls, which are measured separately.

The contents are estimated either by the foot or yard, or square of 100 feet. Enriched mouldings, &c., are rated by running or lineal measure.

Deductions are to be made for chimneys, doors, windows, &c.; but the windows are seldom deducted, as the plastered returns on the top and sides are allowed to compensate for the window opening.

EXAMPLES.

(1*st.*) To how much amounts the ceiling of a room at 10*d.* per yard, the length being 21 feet 8 inches, and the breadth 14 feet 10 inches?

21 - 8
14 - 10
303 - 4
18 - 0 - 8
321 - 4 - 8

9|321·38 *square feet;*
35·7098765 *square yards;*
·0416 £ = 10*d.*
9|2142592593
2386658436
357098765
1428395062
1·48791152286 £;
20
9·7582304573
12
9·098765488 £ 1 - 9 - 9 *Ans.*

(2*nd.*) The length of a room is 18 feet 6 inches, the breadth 12 feet 3 inches, and height 10 feet 6 inches, to how much amounts the ceiling and rendering, the former at 8*d.* and the latter at 3*d.* per yard, allowing the door to be 7 feet by 3 feet 8 inches, and a fire-place of 5 feet square?

18 - 6 *length ;*
12 - 3 *breadth ;*
222 - 0
4 - 7 - 6
226 - 7 - 6 = 9 226·625
25·1805

2 × 18·6 = 37 - 0 *ft.* *ft.* *in.* 643 - 9
2 × 12·3 = 24 - 6 *door* 7 × 3 - 8 = 25 - 8
* 61 - 6 *chimney* 5 × 5 = 25 - 0
10 - 6 50 - 8
613 - 0 593 - 1
30 - 9
643 - 9

593·1 = 9 593·083
65·89
·0125
32945
13178
6589
·823625
·83935
1·662975
20
13·2595
12
3·1120

£ 1 - 13 - 3, *Answer.*

VAULTED AND ARCHED ROOFS.

Arched Roofs are either *vaults*, *domes*, *saloons*, or *groins.*

Vaulted Roofs are formed by Arches springing from the opposite walls, and meeting in a line at the top.

Domes are made by Arches springing from a circular or polygonal base, and meeting in a point at the top.

Saloons are formed by Arches connecting the side walls to a flat roof or ceiling in the middle.

Groins are formed by the intersection of Vaults with each other.

Vaulted Roofs are commonly of the three following sorts :—

First,—Circular Roofs, or those whose Arch is some part of the Circumference of a Circle.

Second,—Elliptical or oval Roofs, or those whose Arch is an oval or some part of the Circumference of an Ellipsis.

Third,—Gothic Roofs, or those formed by 2 circular Arcs struck from different centres, and meeting in a point directly over the middle of the breadth or span of the Arch.

PROBLEM I.

To find the Surface of a Vaulted Roof.

Rule.—Multiply the length of the Arch by the length of the Vault, and the product will be the Superficies.

Note.—To find the length of the Arch, make a line or string ply close to it quite across from side to side.

Example.

How many square yards are in the vaulted roof, the length of the arch being 42·4 feet, and of the vault 106 feet ?

42·4 *arch ;*
106 *length of the vault ;*
2544
424
9|4494·4
499·37 *yards, Answer.*

PROBLEM II.

To find the Contents of the Concavity of a Vaulted Roof.

Rule.—Multiply the length of the Vault by the Area of one end, that is, by the Area of a vertical transverse Section, for the contents.

Note.—When the Arch is an oval, multiply the span by the height, and the product by ·7854 for the Area.

EXAMPLE.

What is the contents of the vacuity of an oval vault whose span is 30 feet and height 12 feet, the length of the vault being 60 feet?

30 *span ;*
12 *height ;*
360
·7854
471240
23582
282·7440
60
16964·640 *Answer.*

PROBLEM III.

To find the Superficies of a Dome.

RULE.—Find the Area of the Base, and double it; then say,—as the radius of Base is to the height of the Dome, so is the double Area of the Base to the Superficies.

NOTE.—For the Superficies of a hemispherical Dome, take the double Area of the Base only.

EXAMPLE.

Required the superficies of a hexagonal sphere dome, each side of the base being 10 feet.

·07958
1000 = 100^2
0795·8 *area.*
2
1591·6 = *double the area ;*

then say, as $\overset{\textit{radius.}}{15·9}$: $\overset{\textit{feet.}}{20}$ *height* : :
1591·6 *double the area of base ;*
20
15·9|31832|2000 *feet, Ans.*
318
32

PROBLEM IV.

To find the Solid Contents of a Dome.

EXAMPLE.

What is the solid contents of a spherical dome, the diameter of whose circular base is 30 feet?

Diameter, 30^2 = 900
·7854
706·86 *feet, Answer.*

PROBLEM V.

To find the concave Superficies of a Groin.

Rule.—To the Area of the Base add $\frac{1}{7}$ part itself of the superficial contents.

Example.

Required the superficies of a groin arch, raised on a rectangular base whose dimensions are 20 feet by 16.

$$\begin{array}{r} 20 \\ 16 \\ \hline 320 \\ 45\frac{5}{7} \\ \hline 365\frac{5}{7} \end{array} \text{ \textit{Answer.}}$$

PROBLEM VI.

To find the solid Contents of a Groin Arch.

Rule.—Multiply the Area of the Base by the height; from the product subtract $\frac{1}{10}$ of itself, and the Remainder will be the contents of the vacuity.

Example.

What is the contents of a vacuity below an oval groin, the side of its square base being 24 feet, and its height 8 feet?

$$\begin{array}{r} 24 \\ \underline{24} \\ 96 \\ 48 \\ \hline 576 \end{array} \qquad \begin{array}{rl} 576 & \\ 8 & \textit{height;} \\ \hline 4608 & \\ \text{subtract } 460{\cdot}8 & = \frac{1}{10} \text{ of itself;} \\ \hline 4147{\cdot}2 & \textit{Answer.} \end{array}$$

Note I.—To find the Solid Contents of Brick or Stone Work which forms any Arch or Vault, multiply the Area of the Base by the Height, including the work over the top of the Arch, and from the product subtract the contents of the Vacuity found by the foregoing problems, then the Remainder will be the contents of the Solid Materials.

II.—In Groin Arches, however, it is usual to take the whole as Solid without deducting the Vacuity, on account of the trouble and waste of materials attending the cutting and fitting them to the Arch.

DETAILED STATEMENTS

OF

Numbers of work-people and quantities of material required for the various kinds of work executed in the Department of Public Works.

REMARKS.

The proportion of labour and materials herein allowed is on a liberal scale and ought not to be exceeded, particularly that for masonry work. Some of the departmental officers believed or were led to believe by their subordinates that 700 bricks of the specified dimensions would not build 100 cubic feet of masonry. In consequence of this assertion I gave a fair trial to the masonry work, whilst making some additions to the Roman Catholic Chapel at Midnapore: I counted out 700 bricks, weighed 6 measures or 26¼ mds. of soorkey and 3 measures or 13⅛ mds. of sifted ghooting lime, under my own personal superintendence and erected 100 cubic feet of plain masonry, after this quantity was completed I found that there were upwards of 20 bricks left and 1¼ measure or about 7 cubic feet of mixed dry mortar; which result will be invariably found by a strict and honest supervision.

The labour also can be lessened by a cooly or two, the builder must however see that the bricks measure 11⅓ × 6 × 2½ inches, after they are burnt, for which purpose they ought to be moulded somewhat larger; as the cutcha bricks shrink a little in the kiln.

Ghooting lime and soorkey are of the same weight; i.e. one measure or 5 cubic feet of ghooting lime will in weight be equal to one measure or 5 cubic feet of soorkey.

D. A. G.

ABSTRACT

OF THE

FOLLOWING DETAILED STATEMENTS OF RATES.

No. 1.—Exhibits the detail of workmen and materials requisite to construct 100 cubic feet of plain pucca masonry with kiln-burnt bricks and mortar in foundation.

No. 2.—Ditto ditto ditto in superstructure to the height of 4½ feet from the ground.

No. 3.—Ditto ditto ditto in ditto to the height of one story or 25 feet.

No. 4.—Ditto ditto ditto in ditto to the height of second story or 45 feet.

No. 5.—Ditto ditto of masonry in foundation with kiln-burnt bricks set in clay.

No. 6.—Ditto ditto of pucca arched masonry.

No. 7.—Ditto ditto of 1000 running feet of pointing below the height at which masons can work without scaffolding.

No. 8.—Ditto ditto ditto to the height of one story or 25 feet.

No. 9.—Exhibits the detail of labour and materials requisite for 100 superficial feet of lime and brick-dust beaten plaster not exceeding 25 feet from the ground.

No. 10.—Ditto ditto between 25 and 45 feet from the ground.

No. 11.—Ditto 100 superficial feet of sand plaster in a lower story not exceeding 25 feet from the ground.

No. 12.—Ditto ditto in an upper story or from 25 to 45 feet from the ground.

No. 13.—Ditto 1000 superficial feet in white-washing (3 coats) interior work.

No. 14.—Ditto 100 superficial feet of lime terrace floor or a 1 brick-flat set in mortar.

No. 15.—Ditto 100 ditto of brick in edge flooring.

No. 16.—Ditto 100 ditto of flat tiled flooring.

No. 17.—Ditto 100 ditto of stone slab flooring.

No. 18.—Ditto 100 running feet of cornice pro. 12 Inches.

No. 19.—Ditto 100 ditto of cornice pro. 2 feet.

No. 20.—Ditto 100 superficial feet of flat roofing.

No. 21.—Ditto 100 superficial feet sloped roofing.

No. 22.—Ditto 100 ditto of ditto (different).

No. 23.—Ditto 100 ditto of pan tiled roofing on bamboo frames with saul rafter.

No. 24.—Ditto 100 ditto of thatched roofing with covering of grass 9 thick on framing of bamboo.

No. 1.

For the construction of 100 cubic feet of plain masonry with kiln-burnt bricks and stone-limes mortar in foundations.

LABOUR.

* ¼ Head Mason.
3 Common Masons.
3 Coolies.
1½ Laborers for excavating and mixing mortar.
½ Bheestie.

MATERIALS.

† 700 Bricks 11½″ × 6″ × 2½″
‡ 3 standard measures of stone-lime.
6 Ditto brick-dust. (sifted.)
Pots, pans and sundries, 2 annas per 100 cubic feet.

If kunkur-lime is used, the proportion will be—

LABOUR.

As above.

MATERIALS.

700 Bricks, (as before.)
4·4 standard measures kunkur-lime.
4·6 ditto brick-dusted (sifted.)
Pots, pans, &c. as before.

---

* Means ¼ day's labour.

† The standard measure for bricks as prescribed in the Chief Engineer Colonel Goodwyn's Circular, No. 59, of 10th October 1854, is 11½ inches × 6 inches × 2½ inches, with which when mortar is used of the proper thickness, four courses will equal 1 foot in height. The cubic contents of a brick = 172·5 cubic inches.

‡ The standard measure to be made 3 feet long, 2 feet wide and 10 inches deep, the contents of which are 5 cubic feet.

NOTES.—Average weight of a brick when properly burnt = 10½ lbs.
" " of a cubic foot of brick masonry from 100 to 115 lbs.
" " of a cubic foot of lime slaked = 44 lbs.
" " of Sand = 90 lbs.
" " of Puzzolana or pounded brick = 70 lbs.

The latter are always more or less combined with water. The ingredients of mortar are always to be used by measure.

NOTE.—A mason can or should execute about 35 cubic feet of plain masonry per day below the height at which scaffolding is used, and about 25 feet per day above that height.

NOTE.—700 Bricks, $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$ = 70 cubic feet.
3 measures stone-lime = 15 cubic feet.
6 Ditto brick-dust = 30 cubic feet.
Total 115 cubic feet.

Or 700 Bricks $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$ = 70 cubic feet.
4·4 measures kunkur-lime = 22 cubic feet.
4·6 Ditto brick-dust = 23 cubic feet.
Total 115 cubic feet.

Which additional 15 cubic feet is allowed for waste and breakage.

No. 2.

To construct 100 cubic feet of Plain Masonry with kiln-burnt bricks and stone-lime mortar to the height at which masons can work without scaffold (about 4½ feet).

LABOUR.

¼ Head Mason.
3½ Common Masons.
4 Coolies.
1 Laborer or Bildar.
½ Bheestie.

MATERIALS.

700 Bricks $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{3}''$.
4·4 measures kunkur-lime.
4·6 ditto brick-dust.
Pots, pans and sundries 3 annas per 100 cubic feet.

If kunkur-lime is used, the proportion will be—

LABOUR.

As above.

MATERIALS.

700 Bricks $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
4·4 Measures kunkur-lime.
4·6 ditto brick-dust.
Pots, pans and sundries, 3 annas per 100 cubic feet.

NOTE.—Such masonry will be either "pointed" or "plastered" on one or both sides, and as the detail of such work is to be found annexed, the particular item can be added to the rate for the masonry, to which it is intended to be applied.

No. 3.

To construct 100 cubic feet of masonry with kiln-burnt bricks and stone-lime mortar to the height of one story or 25 feet.

LABOUR.

¼ Head Mason.
4 Common Masons.
6 Coolies.
1 Laborer or Bildar.
¾ Bheestie.
1 Grammy.

MATERIALS.

700 Bricks, $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
3 measures stone-lime.
6 ditto brick-dust.
Pots, pans and sundries, 3 annas per 100 cubic feet.
Scaffolding, 3 annas per 100 cubic feet.

If kunkur-lime is used, the proportion will be—

LABOUR.

As above.

MATERIALS.

700 Bricks, $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
4·4 measures kunkur-lime.
4·6 ditto brick-dust.
Pots, pans and sundries, 3 annas per 100 cubic feet.
Scaffolding 3 annas per 100 cubic feet.

No. 4.

To construct 100 cubic feet of plain masonry with kiln-burnt bricks and stone-lime mortar to the height of second story or 45 feet, or 20 feet above the height of the last calculation, No. 3.

LABOUR.

¼ Head Mason.
5 Common Masons.
8 Coolies.
1 Laborer or Bildar.
2 Grammies.
1 Bheestie.

MATERIALS.

700 Bricks $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
4·4 measures kunkur-lime.
4·6 . ditto brick-dust.
Pots, pans and sundries, 4 annas per 100 cubic feet.
Scaffolding 4 annas per 100 cubic feet.

NOTE.—For pointing or plastering see Note to No. 2.

No. 5.

To construct 100 cubic feet of plain masonry in foundation with kiln-burnt bricks and set in clay.

LABOUR.

¼ Head Mason.
3 Common Masons.
3 Coolies.
1½ Laborer or Bildar.
½ Bheestie.

MATERIALS.

700 Bricks, $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
Pots, pans and sundries, 2 annas per 100 cubic feet.

NOTE.—From the above, the rate of plain masonry set in clay corresponding to the heights of Nos. 3 and 4 will be known. The "labor" "sundries" and "scaffolding" increasing according to height.

No. 6.

To construct 100 cubic feet of arched masonry with kiln-burnt bricks and stone-lime mortar, including fixing, centering but without plaster.

LABOUR.

¼ Head Mason.
6 Common Masons.
10 Coolies.
2 Laborer or Bildars.
1 Bheestie.
2 Grammies for scaffolding.

MATERIALS.

700 Bricks $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
3 measures stone-lime.
6 ditto brick-dust.
Pots, pans and sundries, 4 annas per 100 cubic feet.
Scaffolding 4 annas per 100 cubic feet.

If kunkur-lime is used the proportions will be—

LABOUR.

As above

MATERIALS.

700 Bricks, $11\frac{1}{2}'' \times 6'' \times 2\frac{1}{2}''$.
4·4 measures kunkur-lime.
·45 ditto stone-lime.
4· ditto brick-dust.
Pots, pans and sundries, 4 annas per 100 cubic feet.
Scaffolding ditto.

No. 7.

1000 running or lineal feet of pointing with lime-cement well ground, below the height at which a mason can work without scaffold.

LABOUR.

5 Masons.
4 Coolies.
6 Boys.
1 Bheestie.

MATERIALS.

·37 Measures stone-lime.
·3 Measures brick-dust.

Pots, pans and sundries, 4 annas per 1000 running feet.

No. 8.

1000 running or lineal feet of pointing with lime-cement well ground to the height of one story or 25 feet, or $20\frac{1}{2}$ feet above No. 7.

LABOUR.

6 Masons.
5 Coolies.
8 Boys.

MATERIALS.

·37 Measures stone-lime.
·3 ditto brick-dust.

Pots, pans and sundries, at 2½ annas per 100 running feet.
Scaffolding, 3 annas per 100 running feet.

NOTE.—1000 running feet pointing of English Bond, equals 150 superficial feet.

No. 9.

100 Superficial feet of lime and brick-dust beaten plaster, ⅜ inch thick, if not exceeding 25 feet above the ground or the height of the lower story.

LABOUR.

2 Masons.
1 Coolie.
3 Boys.
½ Bheestie.
1 Bildar.

MATERIALS.

·8 Measures Hydraulic lime.
·6 ditto brick-dust.

Pots, pans and sundries, 1 anna per 100 superficial feet.
Scaffolding, 1 anna per 100 superficial feet.

No. 10.

100 superficial feet lime and brick-dust beaten plaster, ⅜ inch thick, in a second story or between 25 and 45 feet from the ground.

LABOUR.

3 Masons.
2 Coolies.
5 Boys.
1 Bildar.
½ Bheestie.

MATERIALS.

·8 Measures Hydraulic lime.
·6 ditto Brick-dust.

Pots, pans and sundries, 2 annas per 100 superficial feet.
Scaffolding ditto.

No. 11.

100 Superficial feet sand-plaster with stone-lime and sharp well cleansed sand, ⅝ inch thick, if on lower story, or not exceeding 25 feet from the ground.

Labour.

1½ Masons.
1 Coolie.
2 Boys.
½ Bheestie.

Materials.

·6 Measures stone-lime.
·8 ditto clean sand.
Pots, pans and sundries, 1 anna per 100 superficial feet.
Scaffolding 1 anna per 100 superficial feet.

No. 12.

100 Superficial feet of sand-plaster with stone-lime of sharp well cleansed pit-sand, ⅝th inch thick, if on an upper story, or from 25 to 45 feet above the ground.

Labour.

2 Masons.
1 Coolie.
3 Boys.
½ Bildar.
½ Bheestie.

Materials.

·6 Measures stone-lime.
·8 ditto clean sand.
Pots, pans and sundries, 2 annas per 100 superficial feet.
Scaffolding 2 annas per ditto.

No. 13.

1000 Superficial feet of white-washing (3 coats) interior work.

Labour.

3 Masons.
4 Boys.
1½ Bheesties.
2 Bildars.

MATERIALS.

·2 Measures lime.
$\frac{5}{16}$ Seers of gum.
Pots, cloth, scaffolding, &c. 1 anna per 1000 superficial feet.

No. 14.

100 Superficial feet 6 inch lime terrace floor beaten down to 4 inches, over one brick flat set in mortar.

LABOUR.

¼ Head Mason.
3 Common Masons.
4 Coolies.
8 Boys or Women.
1 Bildar.
1 Bheestie.

MATERIALS.

204 Bricks, 11½″ × 6″ × 2½″.
7 Measures broken brick well burnt (33 bricks equal 1 measure when broken to about 1½ inches diameter).
Pots, pans, &c. 3 annas per 100 superficial feet.

NOTE.—The proportion of Mortar or Cement cannot be here given. The lime must be eminently hydraulic, and the ingredients will therefore depend on the nature of the lime, (vide Colonel Goodwyn's Manual, article "mortar" paras. 76, 88, 89,) the quantity of mortar for the work being, about 6 standard measures.

NOTE.—Cubic contents of 100 solid feet of above work = 58·33 cubic feet.
204 Bricks = 20·4 " "
7 Measures of broken brick or 231 bricks = 23·1 " "
6 Measures of mortar = 30· " "
= 73·5 " "

which allows for beating, wastage, &c.

The substratum is supposed to have been well and solidly prepared before the flat brick is laid down by ramming the earth, beating lime and brick-refuse over it and preparing a layer of sand. This item to be included under the head of "filling in floor" in the estimate.

No. 15.

100 Superficial feet of brick on edge-flooring over 1 course of flat bricks in mortar.

Labour.

¼ Head Masons.
4 Common Masons.
4 Coolies.
2 Boys.
1 Bildar.
1 Bheestie.

Materials.

600 Bricks, 11½″ × 6″ × 2½″.
3 Measures hydraulic lime.
3 ditto brick-dust.
Pots, pans and sundries, 3 annas per 100 superficial feet.

Note.—The same preparation of the substratum is required as for No. 14.

No. 16.

100 Superficial feet of flat-tiled flooring, set in a bed of 1½″ concrete over one brick flat joints, set close in fine cement.

Labour.

¼ Head Mason.
5 Common Masons.
6 Coolies.
2 Bildars.
1 Bheestie.

Materials.

220 Bricks, 11½″ × 6″ × 2½″.
105 Tiles, 12 × 12 × 1½.
2·4 Measures of hydraulic lime.
2·4 ditto brick-dust.
·5 ditto coarse brick-dust for concrete.
Pots, pans and sundries, 3 annas per 100 superficial feet.

Note.—The same preparation of the substratum is required as for No. 14. The tiles to be well rubbed together at the edges to form close joints and the surfaces guaged.

No. 17.

100 Superficial feet stone slab flooring over one layer of bricks laid flat stones, set in a bed of 1½ inches of mortar, laid with close joints.

LABOUR.

¼ Head Mason.
4 Common Masons.
2 Stone Cutters.
6 Coolies.
2 Bildars.
1 Bheestie.

NOTE.—The stones are supposed to be purchased or delivered by the contractor, surface dressed and merely to require the edges to be dressed whilst being laid.

MATERIALS.

220 Bricks, 11½″ × 6″ × 2½″.
100 slabs of stone 12 × 12.
2·5 Measures of stone-lime.
1·25 ditto clean pit sand.
Pots, pans and sundries, 2 annas per 100 superficial feet.

NOTE.—Pit-sand (not too coarse) well cleansed, suits best as cement for stone and should therefore be used, if procurable.

No. 18.

100 Running feet of plain tuscan cornice projecting 12″, and 12″ in depth, not exceeding 25 feet above the ground.

LABOUR.

4 Head Masons.
50 Masons.
50 Coolies.
2 Bheesties.

MATERIALS.

220 Tiles, 18″ × 12″ × 2½″.
450 Bricks, 11½″ × 6″ × 2½″.
2·5 Measures of hydraulic lime.
2·5 ditto of sifted brick-dust.
Pots, pans and sundries, 2 Rs. 4 annas per 100 running feet.

No. 19.

100 Running feet of plain Tuscan cornice 2 feet projection, and 1 foot 8 inches in depth from 25 to 40 feet above the ground.

LABOUR.

10 Head Masons.
150 Masons.
180 Coolies.
8 Bheesties.

MATERIALS.

110 Tiles, 3′ × 12″ × 1½″.
110 Tiles, 12″ × 12″ × 1″.
1600 Bricks, 11½″ × 6″ × 2½″.
10·3 Measures hydraulic lime.
10·2 ditto sifted brick-dust.
Pots, pans and sundries, 4 Rs. per 100 running feet.

No. 20.

To construct 100 superficial feet flat terrace roofing, 4 inches thick, well beaten over two layers of tiles set in mortar.

LABOUR.

¼ Head Mason.
6 Masons.
15 Coolies.
3 Bildars.
2 Bheesties.

MATERIALS.

210 tiles 12″ × 12″ × 1″ (allowing for wastage.)*
7 Measures of broken bricks.
6·3 { ditto hydraulic lime.
6·3 { ditto brick-dust.
Pots, pans and sundries, 2 annas per 100 solid feet.

NOTE.—For proportion of lime and brick-dust, vide Note No. 14.

No. 21.

100 Superficial feet of sloped roofing, a layer of 18″ flat tiles, covered with a layer of Grecian tiles, set in 2½ inches fine concrete.

---

* The lower of the two layers of tiles should be 1½″ inch thick.

LABOUR.

¼ Head Mason.
5 Common Masons.
8 Coolies.
1 Bheestie.
1 Bildar.

MATERIALS.

70 Flat tiles, 18″ × 12″ × 1½″.
105 Semi-cylindrical Grecian tiles.
105 Grecian tiles flat.
6 Large ridge tiles.
3 Measures hydraulic lime.
3 ditto brick-dust.
·5 ditto coarse brick-dust for concrete.
Pots, pans and sundries, 4 annas per 100 superficial feet.

No. 22.

100 Superficial feet sloped roofing; a layer of 3 feet tiles, under a layer of asphalted tiles, the whole covered with Grecian tiles, set in a bed of 2½ fine concrete.

LABOUR.

½ Head Mason.
6 Masons.
11 Coolies.
1 Bheestie.
2 Bildars.
½ Carpenter for frames in which to pour the asphalte on tiles.

MATERIALS.

36 Tiles, 3′ × 1′ × 1½″.
110 Flat Grecian tiles.
100 Semi-cylindrical tiles.
6 ridge tiles.
100 Asphalted tiles 12″ × 12″ × 1″.
3·75 Measures hydraulic lime.
3·75 ditto brick-dust.
·5 ditto coarse ditto for concrete.
Pot, pans and sundries, 4½ as. per 100 superficial feet.

NOTE.—The labour in preparing the asphaltic tiles is included in the price of the tiles.

No. 23.

100 Superficial feet tiled roofing, with 12 inch pan tiles, span not exceeding 20 feet, with square sawn saul rafters and framing of bamboos nailed.

LABOUR.

1 Mason.
2 Bildars.
1 Tiler.
2 Carpenters for rafters and nailing bamboos.
2 Coolies.
2 Boys.

MATERIALS.

30 Ridge tiles.
650 Pan tiles.
·4 Measure hydraulic lime.
·4 ditto brick-dust.
56 Bamboos.
120 Nails, 3 inch, weight $1\frac{1}{4}$ seers.
45 Running feet, square-sawn, saul rafter, 6″ × 4″.
100 ditto Battens 3″ × 2″.
10 ditto Eaves board 7″ × 1″.
10 ditto Battens $1\frac{1}{2}$″ × $1\frac{1}{2}$″.
$\frac{1}{2}$ Seer of *iron* nails.
Pots, pans and sundries, 6 pie per 100 superficial feet.

NOTE.—Trusses are not included in the above rate, as the number, if any required, will be determined by the plan of the building.

No. 24.

100 Superficial feet of thatched roof covering of grass 9 inches thick, on framing of bamboos tied together, exclusive of timber work.

LABOUR.

9 Grammies.
4 Coolies.
1 Bheestie.

MATERIALS.

1,500 Bundles of grass.
90 Picked bamboos.
10 Seers rope.
100 Supfl. feet matting.

NOTE.—The number of bundles of grass required for 100 superficial feet depends entirely on their size, which is variable. In all cases therefore the number required should be fixed by the executive officer having 100 superficial feet executed in his presence, or that of some trusty persons.

C. E.'s Cir. No. 59 *of* 10*th October*, 1854.

☞ The foregoing detailed statements shew the number of workmen and the quantities and descriptions of the materials required for constructing 100 cubic or 100 superficial feet of each kind of work: thus if we require to know what it would cost us per 100 solid or cubic feet to construct any building of plain masonry we have to calculate (vide No. 1,) assuming the wages of the workmen and the rates of the materials to be the following then current, thus:

LABOUR.

	Rs.	As.	P.
¼ Head mason at 4 annas per diem,	0	1	0
3 Common masons at 3 annas per diem,	0	9	0
3 Coolies at 1½ annas per diem,	0	4	6
1½ Labourers at 1½ annas per diem,	0	2	3
½ Bheestie at 2 annas per diem,	0	1	0
Total cost of labour for erecting 100 cubic feet of plain masonry in foundation,	1	1	9

MATERIALS.

	Rs.	As.	P.			
700 Bricks, 11½" × 6" × 2½" at 5 rupees per 1,000,	3	8	0			
3 Standard measures of stone-lime = 13⅓ mds. at 16 rupees per 100 mds.,	2	1	7			
6 Standard measures of soorkee or brick-dust sifted = 26¼ mds. at 8 rupees per 100 mds.,	2	1	7			
Pots, pans and sundries, per 100 cubic feet,	0	2	0			
Total cost of materials for 100 cubic feet,				7	13	2
Thus for the construction of 100 cubic feet of pucca masonry in foundation it will cost Rs. (inclusive of labour and materials,)				8	14	11

N. B.—The rates of labour and materials vary in different stations according to the localities and demand in the market.

NOTES.

Bricks.—8 annas per 1,000 bricks is considered as a very fair rate for moulding; 1,200 mds. of fire-wood either soondry, tamarind or babool are sufficient to burn 100,000 bricks 12″ × 6″ × 3″ out of which 75,000 are expected to turn out good, 400 mds. of wood and 400 mds. of coal will burn a lack of bricks of smaller size.

Ghooting lime.—100 mds. if burnt will yield an outturn of 75 mds. of lime, and 50 mds. of wood are required to burn 100 mds. of ghooting.

The following detail may assist one in forming some idea of making lime out of ghooting.

	Rs.	As.	P.
100 Mds. of ghooting, purchased at 4 Rs. per 100 mds.	4	0	0
100 Mds. of soondry wood at 10 Rs. per 100 mds. ...	10	0	0
Arranging the kiln, emptying the same, slaking lime, sifting after slaking per 100 mds.	2	0	0
Pounding the half calcined ghooting from 8 as. to ...	1	0	0
	17	0	0

To this may be added the cart-hire for conveyance as may be necessary, the price of ghooting and fire-wood varying according to the market rates.

Soorkey.—The rate for pounding 100 mds. of soorkey should not exceed 3 Rs. 8 as. the 100 mds. including sieving or sifting, and it can be done in some localities where labour is cheap for 2 Rs. 8 as. and 2 Rs. 4 as.

750 to 800 Bricks, 12″ × 6″ × 3″ are found sufficient to yield 100 mds. of soorkey; of a smaller size 900 to 1,000.

INDEX OF SOME OF THE PRINCIPAL ORDERS OF GOVERNMENT &c. IN THE DEPARTMENT OF PUBLIC WORKS FROM THE COMMENCEMENT OF THE WORKING OF THE NEW SYSTEM TO THE LATEST DATE.

Overseers Occupying Govt. Bungalows are to pay 7 Rs. a month as rent, and Asst. Overseer 6 Rs. this rule is applicable to the Embankment and Road Departments.	G. O. P. C. No. 367, of 27th June, 1851.
Punkahs Sanctioned for all School Rooms of European troops with the addition of a deep fringe for all barrack and hospital buildings in which they are used.	Govt. of India Mily. Department vide Offg. Under-Secy. Young's Docket No. 1046, of 15th May, 1854 and No. 1496, of 3rd July, 1854.
Barrack furniture for issue to H. M.'s and Hon'ble Company's European troops in place of old furniture requiring repair or renewal; to be kept in store by executive officers to prevent the inconvenience complained of by commanding officers of European Regiments.	Govt. Mily. Department No. 461, of 19th April, 1854.
Dawk Bungalows—the Department P. W. authorized to be relieved of the collection of taxes and the control of the establishment and furniture connected with—and the same transferred to the Postal authorities in compliance with a proposal made by the Director General of Post Offices in India.	Bengal Govt.'s Docket No. 1572, of 10th July, 1854.
Ditto ditto, furniture to be supplied to the same by the Ex. Officer at the requisition of the Postal Department.	Govt. of India's No. 1265, of 12th June, 1855.

Pensions to Uncovenanted Servants.	Vide extract of a despatch No. 18 of 5th May, 1854 from the Court of Directors to the Govt. of India in the Financial Department, also Under-Secy. to Govt. of Bengal's Circular, No. 22, dated 6th June, 1855.
Military subordinates in the D. P. W., when **under arrest,** previously to their being arraigned for trial before a Court Martial, or when under suspension, shall receive the pay, rations, house rent and Family allowance of their rank.	Orders by the Govt. of India vide Mr. Under-Secy. A. W. Russel's docket No. 57, of 9th January, 1855.
Asst. Ex. Engineers permanently appointed to the D. P. W. shall be considered, while on leave, to half staff salary in the same way as other officers in permanent staff appointments.	Bengal Govt. No. 341, of 5th March, 1855.
Standard box for Soldiers to be 24 inches in length. 18 „ in breadth. and 15 „ in depth. Internal measurements. To be provided with a staple for a padlock in preference to the lock fixed in the box.	Approved of by the Hon'ble the President in Council as per orders conveyed in Bengal Government's No. 694, of 13th April, 1855.
Reading-rooms to all European Barracks authorized to be constructed.	Mr. Under Secy. Pratt's Docket No. 849, of 30th April, 1855.
Mileage of one anna to subordinates in the D. P. W. sanctioned to enable them to proceed from the place of examination to Head Quarters of the Divn. to which they may be appointed.	Ditto ditto No. 1152, of 29th May, 1855.
Ditto ditto to the **Students** of the 3rd Department of the **Thomason College** whilst proceeding to join their appointments in the D. P. W. to be paid in advance by the parties applying for their services.	Govt. N. W. P.'s letter No. 1825, of 24th September, 1853.

"No Demand Certificates" are required to accompany applications for leave beyond the limits of the Presidency and all Mily. and Medical Officers entrusted with the disbursement of Public Money in the Civil, Political, Public Works, Pay, Commissariat and Stud Departments having accounts with the Govt. Acctts. at the Presidency or at Agra are specially enjoined to notify their intention to the Mily. Acctt. three clear months prior to the period of their probable departure.	Vide G. O. No. 683, of 25th June, 1855.
Arrears of staff pay to Mily. Subordinates in the D. P. W. authorized when under arrest or suspension on acquittal of the offence charged against them; and to be forfeited for that period by the party who may be convicted, or whose conduct on enquiry should prove unfavorable.	Extract of a Mily. Letter from the Hon'ble the Court of Directors to the Govt. of India, dated 16th May, 1855.
Sundays—all works whether progressing by contract or by departmental agency to be suspended on—except in cases of urgent necessity, which must be reported.	Govt. order, dated 11th January, 1847, vide C. E. L. P.'s Cir. No. 148, of 23rd August, 1855.
Officers in Arrears with their **Accounts,**—penalty that should be inflicted on.—	Secy. to Govt. of India D. P. W.'s letter No. 5040, of the 24th October, 1856.
Descriptive Nomination roll—form of.—	Circulated with C. E.'s No. 90, dated 20th January, 1855.
Office Furniture—to be made up only for the use of Ex. officer's own office and in no others.	Vide Mr. Secy. Grey's letter No. 1427, of 30th June, and C. E.'s Cir. No. 137, of 7th July, 1855.
Roads—regarding the repair and construction of.—	Vide C. E. L. P.'s Litho. Cir. No. 39, of 18th October, 1854.
Code of Structural laws illustrated with plates.	Vide ditto No. 69, of 4th November, 1854.

Fascine Spurs.—Construction of.—	Vide ditto No. 93, of 25th January, 1855.
Sudder ameen's cutchery—Standard plan of a—with a general description of the Building.	Vide ditto No. 94, of 26th January, 1855.
Commissioner's cutchery—Standard plan of a—	Bengal Govt.'s letter No. 78, of 30th November, 1854, vide Chief Engr.'s No. 109, of 26th April, 1855.
Drawings in detail of a **Sky-light** and **Ventilators** applicable to all flat-roofed Buildings.	Vide C. E.'s Cir. No. 122, of 8th June, 1855.
Brick-preparing Machine—description of a—	Vide ditto No. 132, of 2nd July, 1855.
Lightning rods to Buildings and Ships—application of—	Vide ditto No. 155, of 25th September, 1855.
Completion Certificates to be invariably submitted within one month after the date of completion of work.	Vide ditto No. 67, dated 6th September, 1856.
Government Servants are not to be dismissed without orders of superior authority and without a defence.	Vide ditto No. 156, of 29th September, 1855.
Mileage—the charge for—must be supported by a Statement or Journal shewing the places visited clearly with the dates of arrival at and departure from each, and of the distances travelled, with a Certificate, on honor that the journey was made in the discharge of public duty.	Vide ditto No. 69, of 16th September, 1856.
Office Establishments must be compelled to work at extra hours if necessary to prevent arrears.	Orders of Govt. of India, D. P. W. dated 6th February, 1857.
Glass doors authorized generally for the **Staging Bungalows** in Bengal, in concurrence with the opinion of the Director Genl. of the Post Office.	Under Secy. to Govt. of Bengal's letter No. 105, of 11th January, 1856, to the C. E. L. P.

Arsenal Tools—Officers whether Civil or Mily. who depend upon the Arsenal for supplies of such Tools as Mamooties, Khoodallies, Pick axes, &c. are to send to the office of the Inspector Genl. of Ordnance and Magazines yearly as soon as possible after the 1st January, a statement of the number they will probably require in the course of the year.	Extract of General Order No. 125, dated 22nd January, 1856.
Insolvent Court—a resort to—by Uncovenanted Servants of Govt. will be considered, unless under special circumstances, a sufficient cause for exclusion from the Public Services.	Extract from the Proceedings of the Most Noble the Govr. Genl. of India in Council in the Home Dept. under date the 12th January, 1856.
Carriage required for the transport of **Magazine Stores** for the Barrack Dept. shall be supplied by the Commissariat Dept. but must be paid for at once by the Engineer Dept. so that the transactions need not appear at all as a matter of account on Proceedings of the Commissariat Dept.	No. 2048, dated 12th October, 1855, Govt. P. W. Dept. vide C. E.'s Cir. No. 183, of 23rd February, 1856.
Washing house and **urinary** erected in the Punjaub (recd. under cover of the Offg. Town Major's No. 108, of 18th January, 1856,) approved of as a Standard to hold 20 metal washing basins per company instead of 14 per company.	Govt. of India, Public Works Dept. No. 144, of 15th January, 1856, and No. 3564, of 4th August, 1856.
Tentage at the rate of 4 Rs. per diem authorized to the **Civil Engineers** appointed by the Hon'ble the Court of Directors in addition to the horse-allowance sanctioned by the Supreme Govt. (as communicated in Secy. to Govt. No. 1509, of 12th July, 1855.) Tent-allowance to be claimed	Govt. Orders No. 749, of 11th March, 1856.

only when actually in camp maintaining marching Establishments—and Civil Engrs. to provide their own tents.	
Officiating Appointments—Officers filling—the permanent incumbents being on Furlough, shall, in accordance with the spirit of the new Furlough Regulations, draw half Staff Salary for the first six months and the full Staff of the Divn. at the expiration of that period, also that an Officer transferred from one Division to officiate in another Division, the incumbent of the latter proceeding on Furlough, shall receive half the Staff Salary of his permanent appointment and half the Staff Salary of the offg. one for the first six months, and after that period he will draw the full Staff Salary attached to his offg. appointment.	Govt. of India's Orders D. P. W. No. 1102, dated 28th February, 1856.
Relative Rank of Commissioned non-Commissioned and Uncovenanted Asst. Ex. Officers, as to which shall take precedence—decided.	Govt. of India's No. 1917, dated 18th April, 1856, D. P. W.
Barrack Furniture—a deal wood table and two wooden chairs for the use of each married European Soldier and a Barrack Table and two Forms for each European Guard Room authorized throughout the Bengal Presidency according to Standard Drawings. Estimates of which are to be submitted by the departmental Officer in whose Divisions European Troops are located.	Govt. Order No. 1460, dated 23rd May, 1856.
Travelling Allowance of the **Office Establishment** and the carriage of the office tents, furniture and records of Ex. *Engi-*	

neers and officers to be sanctioned by the Chief and Superintending Engineers in cases where it appears to be for the interest of Govt. to do so—charges to be brought forward under the head of contingencies.	Govt. Orders D. P. W. No. 2307, dated 16th May, 1856.
Securities to the amount of 2000 Rs. must be deposited by every person not in the Mily. Service or under covenant to the Court of Directors before he can be permanently employed in the Engineer Dept. and 400 Rs. on the upper Subordinate Establishment to be forfeited in the event of his leaving the Dept. without leave or without giving 6 months' notice.	Vide 74th Para. of G. O. No. 117, of 17th June, 1856.
Rules in reference to the entertainment of **Extra Establishment.**	Vide Extract from the Proceedings of the Rt. Hon'ble the Govr. Genl. in the Financial Dept. No. 3128, of 4th July, 1856, annexed to C. E.'s Cir. No. 209, of 1st August, 1856, L. P. and Supreme Govt.'s Despatch No. 1452, of 20th March, 1857.
Officers in her Majesty's Service employed in the D. P. W. or on surveys requiring **leave beyond sea** and Govt. being willing to dispense with their services for a time should submit their applications through the Commanding Officer for submission to His Excellency the C.-in-C. in the usual manner, the application being accompanied by memorandum from the departmental superior stating that the sanction of Govt. has been obtained to such application and for the period requested.	Ordered by the Rt. Hon'ble the Govr. Genl. as communicated in Bengal Govt.'s docket No. 2571, of 4th October, 1856.

Increase of Establishment—applications for—to be accompanied as a general rule by statements of present work, as an average of three years, as compared with that of the Department ten years previously.	4th Para. of the Hon'ble the Court of Directors despatch addressed to the Govt. of India in the Financial Dept. No. 83, of 17th September, 1856.
Married Men's Barracks.	Vide annexure to Govt. of India D. P. W.'s letter No. 6007, of 26th November, 1856, being copy of a Despatch from the Hon'ble the Court of Directors No. 187, of 5th November, 1856.
Gratuities to the families of lascars, coolies and other workmen in the service of Govt., who may happen to be killed or to die in consequence of wounds or accidents sustained in the execution of their public duties—rules regarding the granting of.	Govt. of India's No. 28, in the Financial Dept., dated 4th July, 1856.
Applications from a Mily. Departmental Subordinate to be permitted to **resign his plan** and return to his regiment to be accompanied by a remark stating whether any thing has occurred to affect the applicant's character.	Govt. of India P. W. D. No. 496, of 26th January, 1857.
All tents and **equipage** for the personal accommodation of officers and subordinates in the D. P. W. will be provided by themselves and at their own cost under the rules laid down in G. O. No. 117, dated 17th June, 1856, (vide page) and tents actually required for the use of the public office establishment of officers will be provided and carried at the public expense.	Ditto ditto, No. 985, dated 24th February, 1857.
Any officer who may have been placed **in the classified list on smaller allowances** than those heretofore drawn by him, will continue until promotion to draw the allowances he drew prior to the 1st November, 1856.	Govt. of India's D. P. W. No. 396, of 20th January, 1857.

Mathematical Instruments to subordinates of or above the rank of Assistant Overseers in the D. P. W. when detached from Head Quarters authorized to be supplied by Government.	C. E. L. P.'s No. 253, of 21st April, 1857.
Medical Attendance. A Mily. officer residing in a Cantonment though in civil employ, is entitled to gratuitous medical attendance from the Mily. Staff Surgeon, if there be no Civil Surgeon in the same station. Gratuitous medical attendance which under the Notification No. 107, of 18th January, 1856, is allowed to the families of Mily. officers not in civil employ shall be extended to the families of all Non-Commissioned officers; whether they be in civil employ or not. Fees for medical attendance on the families of public servants is left in all cases to private adjustment.	Supreme Govt.'s Order Home Dept. No. 450 of 24th March, 1857.
Taking up land for **public purposes** rules prescribed for.	Govt. Orders No. 2028, of 6th August, 1856.
No Gratuity is to be given to those who have served **less** than **5 years,** and to others gratuities are to be granted proportioned to the length of service but in no case to exceed 6 months' pay, consequent on the loss of appointment for no fault but by reason of the abolition of their office.	Govt. Orders, Financial Dept. dated 19th March, 1855.
Probationary appointments are to be considered in the same light as officiating appointments to which the privilege of half salary while on leave is not attached.	Orders of Supreme Govt. as communicated in Bengal Govt.'s docket No. 2351, dated 16th May, 1857.

Uncovenanted Servants in the employ of Govt. whilst **under suspension** are entitled to receive one-fourth only of their regulated salaries, the subsequent grant of any additional account being reserved for the consideration of Govt. on the decision come to regarding the offence for which their suspension might have taken place.	Govt. Orders P. W. D. No. 94, of 2nd June, 1857.
Pay and allowances to be drawn by officers of the D. P. W. of all grades when **in transit** from one charge to join another.—If transferred in the same salary to draw the full salary during period of transit. If transferred to a higher paid appointment to draw the full salary of the last appointment during period of transit and not entitled to the increased allowances of the new appointment until he takes charge of the office. In addition to the above, he is entitled to draw travelling allowances under the ordinary rules at a daily, monthly or Mileage rate as the case may be, with this proviso, that he has not been transferred on account of any misconduct and that he has used every reasonable dispatch in joining his new appointment which must be certified by the C. E. or the officer under whom he has been transferred.	Vide Govt. D. P. W. Orders dated 1st May, 1857, annexed to C. E. L. P. Cir. No. 267, of 9th June, 1857.
Punkahs and **Tatties** authorized to be provided and **Bheesties** to be entertained by the Ex. Engineers for the use of their officers during the hot season, the charges to be brought forward in the usual contingent bills.	Govt. of India Financial Dept. No. 1904, dated 30th April, 1857.

Office Establishments of Ex. Engrs. or other public officers when absent from their fixed stations on duty in camp are entitled to an allowance when travelling of 3-10ths of their monthly salaries subject to the approval of Chief Engr.	Secy. to Govt. of India D. P. W.'s letter No. 3169, of 30th June, 1857.
Officers of the **upper subordinate Grade** of the D. P. W. holding executive charge of a division, are to draw an allowance of 100 Rs. per mensem, in addition to the pay of their rank drawing the travelling allowance of the grades in which they officiate.	Secy. to Govt. of India D. P. W.'s No. 2198, of 4th May, 1857.
Officers of the **D. P. W.** when employed at the charge of **private Persons** of **local funds** or **foreign service** whose salaries are for the time being chargeable to the same will nevertheless draw their salaries as usual audited and charged in the Public Works account—a set-off being entered *per contra* of the amount which will be passed to the credit of the Public Works from the local or private funds either on a cash-payment or book-transfer as the case may require.	Secy. to Govt. of India, D. P. W.'s No. 3867, of 7th August, 1857.
Tolls levied on **roads, ferries** and **Bridge of Boats.**—Rules regarding—	Secy. to Govt. of India, D. P. W.'s No. 1639, of 10th April, 1857.
Officers of the D. P. W. when on **field** or **Foreign Service** and temporarily withdrawn from their appointments shall receive half their staff salaries	Orders of the Supreme Govt. of India in the Financial Dept. No. 2894, dated 26th June, 1857.

Examination in the **Vernacular Languages**—Committees prohibited from granting a "qualified" certificate to officers in the D. P. W.—their report should be definite and to the effect, that the candidate either has or has not attained the prescribed knowledge of the language in which he has been examined.	Orders of the Supreme Govt. No. 3187, of 30th June, 1857.
Standard Plan of a **Regimental School** for Stations in the Plains.	Circulated with Govt. of India P. W. D.'s No. 3632, of 17th July, 1857.
Convict Labour—instructions as to how the value of—employed in the execution of Public Works will be assessed, charged and adjusted in the accounts of the D. P. W.	Govt. of India P. W. D. Cir. No. 3913, of 14th August, 1857.
Office Rent (not house rent) to be drawn by a Supdt. of Public Works of more than one executive charge Rs. 30 per mensem. First and 2nd Class Ex. Engrs. .... 30 0 0 Third and 4th Class Ex. Engrs. .... 20 0 0 Road officers according to their Standing in the classified list, Surveyors having Clerks and Draftsmen requiring shelter, ... 20 0 0 N. B.—The above is only to be drawn in case where a house or a room is actually furnished by the Ex. officer for the use of the office.	Govt. of India P. W. D. Cir. No. 4946, of 25th September, 1857.
Paper Securities—to be in future endorsed over to the Secretary to the Govt. of India P. W. D. instead of, as heretofore, to the Secy. Govt. of Bengal.	Bengal Govt.'s Docket No. 2258, of 8th October, 1857.

Free Quarters—Govt. Officers not entitled to—should be advised by the Executive Engineers of the rent of any available Public Buildings that they may wish to occupy. Rent to be duly realized and not allowed to fall in arrears.	Orders of the Hon'ble the Court of Directors communicated in Govt. of Bengal's No. 2498, of 31st October, 1857.
Standard Plans of **Barracks** and **Hospitals** for stations in the Plains.	Circulated with Bengal Govt.'s Docket No. 688, of 9th March, 1858.
Military Court of Requests—Mily. Subordinates in the D. P. W. are not amenable to the jurisdiction of.	Extract Para. 2nd of a Memo. No. 110, dated 16th February, 1858, by the Judge Advocate Genl. received with the Adjt. Genl. of the Army's letter No. 508, dated 4th March, 1858.

INDIA

SERVICE PENSIONS.

Admission of Servants in the Public Works Department. Limit of Amount of Pension.

Fort William, Financial Department.

The 19*th May,* 1855.

Read a Despatch from the Hon'ble the Court of Directors, No. 21, of 1855 dated the 28th February.

Resolution.—The Hon'ble the President in Council is pleased to resolve, that in accordance with the orders conveyed in the Despatch above mentioned, such of the Uncovenanted Servants employed in the Public Works Department as receive above 10 Rs. per month of salary, shall be entitled to superannuation pension under the provisions of the Pension Rules of the 4th of January, 1831, and that in no case (as respects persons hereafter appointed to the Uncovenanted Service) shall a larger pension than £400 or Rupees 4,000 per annum be granted to Uncovenanted Servants receiving salaries of 700 to 1,000 Rupees a month, nor a larger pension than £500 or Rupees 5,000 per annum to Uncovenanted Servants receiving salaries above that amount, whether the retirement be from ill-health (after either 20 or 30 years' service,) or without a medical certificate after 35 years' service.

Extract from a Despatch from the Honorable the Court of Directors, addressed to the Government of India in the Financial Department No. 75, *of* 1855 *dated the* 15*th August.*

Para. 2nd. As the strict application of the term "continuous service" might operate injuriously in the case of a deserving Uncovenanted Servant when the time arrived for his retirement, you have very properly referred this question for our decision.

Letter from, dated 8th March, 1855.
No. 28.

Submit copies of papers on the question of what is to be regarded as continuous service on the part of the Uncovenanted Servants of Government, and what constitutes such interruption of continuity of service as will invalidate a claim on the part of an Uncovenanted officer to a Service Pension.

3rd. If an Uncovenanted Servant be dismissed for misconduct, and be subsequently readmitted to employment, his first service is not to count for pension. But with this exception, we shall allow twelve months to elapse between the two periods of service without the servant's forfeiting his claim to count the first period, as well as the second, towards the retiring pension. The privilege however of so reckoning the time of service can only apply to two periods. If there is any other interval, the service that may follow cannot be counted as continuous.

(True Extract.)
(Signed) G. G. MORRIS.
Under-Secy. to the Govt. of Bengal.

Extract from a despatch from the Hon'ble the Court of Directors addressed to the Govt. of India in the Financial Department, No. 38, *dated* 13*th May*, 1856.

Para. 43. The subject here reported has been decided in our despatch in this Department, dated 5th December, 1855. No. 107.

Letter from—dated 10th September, 1856, No. 123. Report Pro. in this Dept. (Financial) for the first quarter of 1855, 123 and 126. Forward correspondence with the Govt. of Fort St. George, on the question, whether Uncovenanted Servants should be allowed to count as service qualifying for pension, the periods of authorized absence.

44. It appears to have been the practice at Madras to permit all absence of Uncovenanted Servants, on authorized leave, to reckon as service for pension. Although this has been put a stop to, we should not consider it just to allow those Uncovenanted Servants who may have enjoyed the advantage beyond the limit fixed by the new rule to be now deprived of counting their past leave as service.

AMENDED FORM.

Register of an Application for a Superannuation Pension from the Establishment of — under the Rules passed by Government, under date.

Preferred.

Name of the Person by whom the Pension is applied for, with the name of his Father.	Number on the Establishment.	Identification of applicant's Person.	Size.		Age of applicant at the time of application.			Religious Caste or Tribe.	Where residing.			Present Employment.	Total Period of Service.		Applicant's Service continuous or not.	How long unemployed and under what circumstances.	Date of application to Government.	Average Salary or authorized official allowances per mensem for the five years preceding the date of application.	Salary or authorized official allowance per mensem at the time of application.	Abstract of the grounds of application.	Remarks by the Head of office.	Proposed amount of Pension per mensem.	Treasury at which the party if pensioned wishes to draw his pension.	Orders of Government.
			Feet.	Inches.	Years.	Months.	Days.		Province.	Pergunnah.	Village.		Years.	Months.										
		Indelible marks and other signs or natural defects.																						

(Signature of the Head of the Office.)

N. B.—It must be understood that this Register is not to supersede the detailed information required by the Pension Rules.

(True Copies.)

UNCOVENANTED SERVICE LEAVE RULES.

Extracted from the Calcutta Gazette, Page No. 303.

No. 9.

NOTIFICATION.

Fort William, Financial Department.

The 22nd February, 1856.

Read a Despatch from the Hon'ble the Court of Directors No. 107, of 1855, dated the 5th December.

RESOLUTION.—The Hon'ble the Court of Directors having approved with certain modifications of a code of Rules recommended by this Government for regulating leave of absence and acting allowances to public officers in India not in the Covenanted Service of the East India Company, the Most Noble the Governor General in Council is pleased to resolve that the following rules, together with the despatch above adverted to, be published in the Official Gazette for general information, and be held applicable from the date of the publication of the Notification to all officers in the Uncovenanted Service of the Government who may be in receipt of salaries of Rs. 100 a month and upwards.

Financial Department.

No. 107, of 1855.

OUR GOVERNOR GENERAL OF INDIA IN COUNCIL.

1st. We have carefully considered the papers accompanying your letter noted in the margin* relative to the proposed enactment of rules for the regulation of leave of absence, &c. to the large and increasing classes of public officers, not in the Covenanted Service of the East India Company, but nevertheless, in many cases performing duties of great importance and responsibility. It is scarcely necessary to observe, that we desire to treat them in this, as

* Letter from, dated 28th July, 1855, No. 101. Forward the report of a special Committee consisting of the Mily. Auditor Genl., the Secretary to the Govt. of Bengal, and the Acctt. to the Govt. of Bengal, which was appointed by the Government to consider the subject of framing a code of Rules for the Regulation of leave of absence, and acting allowances for the uncovenanted service, and express an earnest hope that the proposed code may receive the Court's sanction.

in all other respects, with the utmost liberality and consideration, that may be consistent with the interests of the public service.

2nd. Adopting as a principle to be inviolably maintained, that in each separate case of absence of an Uncovenanted officer, the expense occasioned thereby is to be defrayed out of the absentee's salary, we are prepared to concur in the grant to Uncovenanted Servants (receiving Rs. 100 per month and upwards) of the advantages as respects sick leave and leave on private affairs proposed in the code under consideration. The advantages may be concisely stated as follows:

1st. **Sick Leave.**—The grant of leave for three years altogether, during the entire period of service, of which two years only may be continuous or reckon as service for pension. During one year of absence, the absentee to be subjected to the deduction of half, and during the remaining period, of two-thirds of his allowances, provided that he shall in no case draw a larger sum than Rupees 6,000 (£600) per annum.

The maximum being thus fixed, we shall leave it to the local Government, in the exercise of their discretion to determine in each case, how far the advantages of the Rules should be modified with reference to the length of service of the applicant and other circumstances. We desire, however, that, after a continuous absence of two years on sick certificate, an interval of two years shall elapse before further leave on that account is granted.

2nd. **Leave on Private Affairs.**—The grant of leave for one month, in each year, without deduction; for six months on sufficient cause being shown with deduction of half allowances, provided the rate of Rs. 6,000 (£600) per annum be not exceeded; and under special circumstances, for twelve months, without forfeiture of appointment, but without pay and without the leave counting as service for pension.

This latter advantage may we think be fairly conceded in special cases to Uncovenanted Servants, since a regular furlough on private affairs cannot be granted to them, and the loss of their appointments involves practically the loss to them of the service.—But it should not be allowed more than once during the period of service.

3rd. We accede to your suggestion, that Heads of Offices, in cases of urgency, may be authorized to grant leave of absence, on Medical Certificate, to the extent of one month, provided the same be immediately reported for the sanction of Government.

4th. The Rules proposed regarding the allowances of persons appointed to act for *absentees* appear unobjectionable.

We are,
Your affectionate friends.
(Signed) E. MACNAGHTEN,
W. H. SKYES, and
Eight other Directors.

London, the 5th December, 1855.

Rules for regulating leave of absence and acting allowances to Public Officers in India, not in the Covenanted Service of the East India Company.

CHAPTER I.

RULES FOR APPLICATION OF LEAVE OF ABSENCE.

SECTION I.—Leave of absence to officers not in the Covenanted Service of the East India Company, receiving their appointments direct from Government, will be granted by the Government only under which office is held, on application made publicly through the regular channel in the Department to which the applicant may belong; but in respect of all other officers, it will be optional with local Governments to delegate to heads of offices or departments power to act upon the rules without special reference to higher authority.

SECTION II.—Absence without leave will render the absentee liable to loss of appointment, and will be attended with entire forfeiture of salary for the whole period of such absence.

SECTION III.—No leave of absence shall have any retrospective effect, except in cases of severe illness, to be attested by Medical Certificate, conforming in every respect to the directions contained in Section IV.

CHAPTER II.

RULES FOR SICK LEAVE.

SECTION IV.—When an application for leave of absence is made on the ground of ill-health, it must be accompanied by a statement of the case from the medical man by whom the applicant has been attended, distinctly stating from personal observations the nature of the disease, the symtoms by which it is manifested, the causes by which it has been probably produced, and the period during which it has existed so far as the knowledge of the medical officer extends, and by a certificate from the chief medical officer of the station or district, or if at a Presidency town, from a Presidency or rather official surgeon, certifying after careful personal investigation, the necessity for temporary removal and the period for which absence is, to the best of his judgment, absolutely requisite for restoration to health. If the requisite leave be for a larger period than six months, the certificate must in the first instance, be countersigned by Superintending Surgeon of the Divisions in which the applicant may be located, and in cases of leave beyond Sea be afterwards submitted with the statement of the case, for the consideration and countersignature of the members of the Medical Board. The certificate shall be given in the following form:

I, A. B. Surgeon at or of ——, do hereby certify that E. F. (here enter designation of office) is in a bad state of health, and I solemnly and sincerely declare, that according to the best of my judgment, a change of air is essentially necessary to his recovery, and that the circumstances of his case are such, as to render leave of absence for the period of ——— absolutely necessary (or highly desirable.)

The following form shall be observed by the Superintending Surgeon and Members of the Medical Board, in countersigning the certificate.

I (or we) do hereby certify, that according to the best of my (or our) professional judgment, after careful consideration of his case, I (or we) believe the state of health of E. F. to be such as to render leave of absence for a period of ——— absolutely necessary (or highly desirable) for his recovery.

An application for extension of leave must, if the applicant be in India, be accompanied by a certificate to a like effect from the medical officer by whom the applicant is attended, together with a statement shewing sufficient reason for the extension solicited; and such certificates must be countersigned by the Members of the Medical Board, or by the Superintending Surgeon of the Division in which the applicant may be located. In like manner, if the applicant shall have proceeded beyond the Territories under the Government of the East India Company, he must furnish a certificate and statement to the required effect from a surgeon or physician at the places of his temporary residence, by whom he has been attended, such attendance and the period of it to be stated, and the certificate to be countersigned by the examining physician of the East India Company if the absentee is in Europe, or by the principal medical authority of the colony or country to which the absentee may have proceeded, or some sufficient reason stated for the want of such countersignature if not produced.

The officer countersigning must either personally examine the applicant or state some sufficient reason why he has been unable to do so; when any of the required particulars are neglected, leave will be refused.

SECTION V.—Leave of absence will be granted under the following limitations to Servants, who may be declared by a sufficient medical certificate to require leave for the restoration of their health.

1st. The limit to leave on medical certificate is fixed at three years, during the entire period of service, of which not more than two years may be continuous, and two years only will be permitted to reckon as service qualifying for pension.

2nd. Leave of absence on medical certificate will not be granted for a larger period than twelve months at any one time, which may, however, be extended if necessary under renewed medical certificate for periods not exceeding 6 months within the limit of two years continuously. After a continuous absence of two years on medical certificate, an interval of two years shall elapse before further leave on that account is granted.

3rd. During one year of the entire period of absence under this rule, the absentee will be subjected to a deduction of one half, and during the remainder to a deduction of $\frac{2}{3}$rds of his allowances provided, however, that he shall in no case draw a larger sum than Rs. 6,000 (£600) per annum.

4th. In cases of extreme urgency, the heads of offices are authorized to grant leave of absence on medical certificate to the extent of one month, provided the same be immediately reported for the sanction of Government.

CHAPTER III.

RULES FOR LEAVE ON PRIVATE AFFAIRS.*

Section VI.—Leave of absence may be granted for one month in each year, or to Judicial officers during the authorized closing of the civil courts, without deduction from salary.

Section VII.—In addition to the above, and on sufficient cause being shown, leave of absence may be granted on private affairs for not more than 6 months; $\frac{1}{2}$ the absentee's salary being deducted for such period of absence, provided the rate of Rs. 6,000 (£600) per annum be not exceeded.

Clause II.—The leave granted under this Section will be computed from the date of the absentee's quitting his post to the date of his return thereto; a second leave of the same description cannot be taken, till the expiration of 6 years from the date of return to duty from a former leave; no portion of the salary allowed to be drawn will be claimable till the absentee shall have returned to his duty.

Clause III.—Leave taken under this and the preceding Section will reckon as service qualifying for pension.

Section VIII.—In addition to the leave which may be granted under the preceding rules on medical certificate or private affairs,

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* Vide subsequent orders dated 27th June, 1857, (page 217) relative to leave on private affairs.

Government may at any time, under special circumstances and at its discretion, grant leave of absence once during the period of service, not exceeding 12 months on private affairs, without forfeiture of appointment, but without pay. Such period of absence not to count as service, towards pension.

SECTION IX.—No leave of absence on private affairs shall be claimable by any party whatever, under these rules as a matter of right. Such leave will be granted only at the pleasure of the Government or its authorized officers, when the concession of the indulgence, in no way interferes with the interests of the Public Service; and it shall be the duty of the Government in every instance (except in the case of leave granted under Section VI.) to consider and determine whether the grounds of the application are sufficiently urgent to justify the concession of the leave.

SECTION X.—Parties who may desire, to draw their allowances, while absent on leave, will be required to give security in such amount and form as may be fixed by Government, for the refund of any excess that may be drawn in case of their coming under retrenchment.

CHAPTER IV.

RULES FOR ALLOWANCES, &c.

SECTION XI.—No person appointed to a situation under the Government shall draw the salary of his appointment for any period prior to the date of his joining it.

SECTION XII.—An officer holding a situation appointed to one of equal or higher value will, until he joins, draw so much of the salary of his new office as may be equal to the salary of his former situation, provided he does not exceed the time allowed for joining under the following rules; should he do so, no salary will be passed to him for such period in excess.

SECTION XIII.—The time ordinarily allowed for joining an appointment, is to be calculated at the rate of 15 miles a day, Sundays excepted, together with a week to prepare for the journey, but on occasion of emergency, it will be optional with the Government to prescribe the period within which any journey is to be performed.

Section XIV.—A person officiating temporarily in any situation will draw so much of the salary of such situation as may equal the sum deducted on account of absence from the real incumbent, and the substantive allowances of every officer temporarily acting in a situation of superior emolument will be subject to deduction at the same rate; *but no additional expense is on any account to be incurred by the absence of any officer on leave.*

By Order of the Most Noble the Govr. Genl. in Council.

(Signed) C. Hugh Lushington,
Secy. to the Govt. of India.

No. 36.

Fort William, Financial Department, the 11*th July*, 1856.

Regarding leave granted on medical certificate to Uncovenanted Servants proceeding to Europe.

Notification.—It is hereby notified for general information, that the Right Hon'ble the Governor General of India in Council has been pleased to resolve, that in the case of an Uncovenanted Servant proceeding to Europe, on leave on medical certificate, under Section V. of the Uncovenanted Service Absentee Rules, the leave shall be computed from the date of the sailing of the vessel on which he may have embarked from any port in India, which is not more distant from his station, than the port of his own Presidency, to the date of his arrival at any port within the Presidency to which he belongs, or at any other port which is not more distant from his station than the port of his own Presidency.

2nd. His Lordship in Council is also pleased to resolve that, for the interval elapsing between departure from station to the commencement of reckoning absence, or between the end of reckoning absence, and re-arrival at station, special leave shall be allowed, calculated at the rate of one day for every 15 miles of the distance to be travelled, provided that the total period of such leave shall

shall have been spent *bonâ fide* between the place of departure and the place of destination.

The special leave thus granted will be allowed to count as service qualifying for pension, and the absentee will during such leave be entitled to draw the same salary as is allowed by clause 3 of Section V. of the Uncovenanted Service absentee rules.

Order by the Lieut.-Governor of Bengal, 11th August, 1856.

The following extract from the proceedings of the Supreme Government in the Financial Department is published for general information.

Annual returns to be furnished to Civil Auditors &c. of leave granted; on 1st May.

Resolution.—With a view to ensure a correct calculation of the period of service entitling Uncovenanted Servants to pension, the Right Hon'ble the Governor General in Council is pleased to direct that the heads of public offices and departments under the control of the several governments be instructed to furnish on the 1st May of each year to the Civil Auditors and Military Auditors General of the several Presidencies, an annual return, shewing the leave of absence granted during the year under the new Uncovenanted Service Absentee Rules to those Uncovenanted Servants whose leave may not have been notified in the Gazette.

(Signed) W. GRAY.

Fort William, Financial Department, the 29th August, 1856.

Leave by instalments.

Resolution.—The Government of Bombay having solicited orders, with reference to the ruling of this Government dated the 20th June last, on certain points connected with Section VI. of the Uncovenanted Service leave rules, whether, in the event of an Uncovenanted Servant taking privilege leave in one year by instalments, it is necessary, before granting him leave in the following year (either by instalments or for a whole month,) that 11 months shall elapse after the termination of the last instalment taken by him in the previous year; the Right Hon'ble the Governor General in Council is pleased to determine, that an Uncovenanted Servant, taking privilege leave by instalments in one year, may be allowed privilege leave in the following year, if for a whole month at the expiration of 11 months, or if by instalments, after 6 months from the termination of the last instalment taken in the preceding year.

Published by Order of the Right Hon'ble the
Governor General in Council.
(Signed) E. DRUMMOND.

Uncovenanted Servants exceeding privilege leave to forfeit all pay and allowances and if absent for more than one month to lose appointment.

No. 206 of 1857.—The following Notification from the Financial Department is published in General Orders No. 6, dated 23rd January, 1857.

The following extract from a Resolution, passed by the Right Hon'ble the Governor General in Council, under date the 23rd January, 1857, is published for general information.

As a general rule His Lordship in Council, prescribes that in cases when Uncovenanted Servants exceed by a few days the period of their privilege leave the rule obtaining in the case of Covenanted officers shall be applied; that is to say, if an Uncovenanted Servant shall not return at the expiration of his privilege leave, he shall forfeit all pay and allowances during the time of his remaining so absent without leave; and if he shall so continue absent for more than one month beyond the time granted his office shall become vacant.

Calcutta Gazette, page 229.

No. 11.

Fort William, Financial Department, the 6th February, 1857.

Regarding the granting of leave of absence to Uncovenanted Servants drawing less than 100 Rupees per mensem.

Notification.—Read an endorsement from the Home Department, No. 122, dated the 23rd ultimo, forwarding for consideration and orders a letter No. 14, dated the 7th Idem from the Chief Secretary to the Government of Fort St. George, having reference to the absence of Uncovenanted Servants drawing salaries or less than 100 Rs. a month.

Resolution.—On the 25th July last, it was resolved by this Government, with a view to ensure a correct calculation of the periods of service entitling Uncovenanted Servants to pension, that the heads of public offices and departments under the control of the several governments should furnish on the 1st May, of each year to the Civil Auditors and the Military Auditors General of the several Presidencies, an annual return, shewing the leave of absence granted during the year (preceding) under the new Uncovenanted Civil Service Absentee Rules, to these Uncovenanted Servants whose leave might not have been notified in the Gazette.

Referring to this Resolution, the Government of Madras observes, that as the new rules are restricted in their operation to Uncovenanted Servants in the receipt of salaries of Rs. 100 a month and upwards, the above orders would not appear to apply to Uncovenanted Servants whose salaries are below that amount, and that if such be the intention of this Government, there is nothing to prevent the entire periods of absence of Uncovenanted Servants of the latter class counting as service towards pension, definite orders, however, are solicited on this point; and also on a question raised by the Civil Auditor at Madras, "whether it is not left optional with the heads of offices to grant leave of absence to persons whose salary is less than 100 Rupees a month, for a limited period, either on sick certificate or private affairs, making such stoppages as they may think proper, the stoppages thus made being paid to the individuals performing the duties of the absentee, and no extra expense being incurred to the state."

On this solicitation of the Government of Madras, the Right Hon'ble the Governor General in Council is pleased to direct that, in granting leave of absence either on medical certificate or on private affairs to Uncovenanted Servants whose salaries are less than 100 Rupees per month, the heads of offices shall be guided by the spirit of the Rules prescribed for those servants who are in the receipt of salaries of Rupees 100 a month and upwards; that all cases in which leave is so granted to Uncovenanted Servants whose salaries are less than 100 Rupees per month, shall be reported to the Civil Auditor and the Military Auditor General respectively in the manner prescribed in the orders of the 25th July last; and that all past leave enjoyed by any such Uncovenanted Servant shall be counted as service under the orders of the Hon'ble the Court of Directors noted in the margin, although such leave may have exceeded the period allowed under the new Uncovenanted Civil Service Absentee Rules.

Para. 44, of Court's Despatch No. 38, of 1856, dated 13th May, published in the Calcutta Gazette of the 16th July last, page 1136.

Fort William, Financial Department, the 27th June, 1857.

Uncovenanted Officers entitled to leave in accumulation.

Notification.—The following extract from the Hon'ble the Court of Directors, addressed to the Government of India in the Financial Department, No. 28 of 1857, dated the 17th April, 1857, is published for general information:

Para. 1st. We concur in your having ruled, that leave on private affairs cannot be taken by Uncovenanted Servants in continuation of privilege leave.

2nd. With regard to the revision of Section 6, Chapter III. of the rules, we do not object to allow the privilege leave of Uncovenanted Servants to accumulate up to three months as a maximum period. But if the leave of one month

Letter from, dated 17th October, 1856, No. 145, Submit copy of a letter from the Government of Bengal referring for decision two questions connected with the Uncovenanted Service Absentee Rules.

in the year be not taken in one period, we cannot permit it to be divided into more than two instalments,—we append the note in the shape in which we are prepared to sanction it, viz.:

Section 6, Clause I.—"Leave of absence may be granted for one month in each Calendar year without deduction from salary, provided that the indulgence can be granted without injury to the public service, or additional expense to Government. Those servants who may not have occasion to apply for the whole month's leave at once, may divide it into two instalments. No second leave shall be granted under this rule until the completion of eleven months from the expiration of the last leave, if taken at one time, or from the date of return of any sick leave, or leave on private affairs; or if the leave be taken in instalments, until the completion of six months from the expiration of the last instalment. Uncovenanted Servants not availing themselves of the indulgence in any one year, may at the option of the local Government, obtain under the like conditions leave of absence for two successive months, to commence at or after the expiration of twenty-two months from the termination of their former leave; and if two years elapse without enjoyment of the privilege; leave for three months, may, in like manner, at the option of the local Government, be granted at the expiration of thirty-three months from the termination of the last preceding leave; but no leave shall be granted under this rule for any period exceeding three months. If a servant shall not return at the expiration of the period of leave granted him under this rule, he shall forfeit all pay and allowances, during the time of his remaining so absent without leave; and if he shall so continue absent for more than one month beyond the term granted, his office shall become vacant."

Clause 2nd. Officers of the Judicial Department taking leave during the authorized closing of the Civil Courts, will be allowed to draw full salary during such leave, but will not be entitled, in addition thereto, to privilege leave under the 1st Clause of this rule.

By Order of the Right Hon'ble the Governor General in Council.

C. Hugh Lushington,
Secy. to the Govt. of India.

No. 2520.

Extract from the Proceedings of the Right Hon'ble the Governor General of India in Council in the Financial Department under date the 12th June, 1857.

Casual leave for a few days can be granted by the Head of the office in case of sickness at his discretion without loss of salary.

Read an Endorsement from the Home Dept. No. 795, dated the 21st ultimo, forwarding for consideration and orders, a letter from the Acting Chief Secretary to the Govt. of Bombay No. 2208, dated the 6th Idem having reference to a question connected with the Uncovenanted Civil Service Absentee Rules. Resolution—the Right Hon'ble the Govr. Genl. in Council observes that the Govr. of Bombay issued a Circular on the 27th June, 1856, declaring that nothing contained in the Uncovenanted Service Absentee Rules is intended to prevent Heads of offices from granting casual leave of absence from office without deduction of salary to any subordinate officer, who without leaving his station, may be compelled to remain at home from sickness for a period not exceeding twenty days in the year whether continuous or at intervals; that if such casual absence exceed twenty days, the Absentee should be subject to a deduction of one-fourth of his salary for the period in excess of such twenty days, provided that the entire absence does not exceed two months in the year, and that if such absence exceed two months in the year, the Absentee should be considered as falling under the Uncovenanted Service Absentee Rule.

Referring to this Circular, instructions are solicited as to whether the excess beyond twenty days' leave, as it is subjected to a deduction of one-fourth of salary, should in calculating period of service for pension purpose, be taken or not into account, as part of the two years allowed by Clause 1 of Section V. of the Uncovenanted Service Absentee Rules, the same as leave of absence on medical certificate granted under these Rules.

The Rt. Hon'ble the Govr. Genl. in Council observes, that under the strict bearing of the Rules, all leave under sick certificate has to be taken into account as part of the two years allowed by Clause 1 of Section V. and seeing that the Circular issued by the Govt. of Bombay involves a modification of Rules; His Lordship in Council is of opinion, that it should be cancelled, it being understood however that casual leave for a few days may in case of sickness be granted by the Head of the office at his discretion, without loss of salary; and without such leave being taken into account as part of the two years allowed by Clause 1 of Section V.

Order.—Ordered that a copy of the foregoing Resolution be sent to the Home Dept. for communication to the Govt. of Bombay.

COPY.

No. 4796, *of* 9*th November*, 1857.

To

W. P. PALMER, ESQ.

Civil Auditor.

Fort William.

Financial Department.

SIR,

Deductions from salaries of ALL UNCOVENANTED SERVANTS for leave granted in excess of the few days allowed in the Financial Resolution No. 2520 of 12th June, 1857, are to be made in strict accordance with Rules and to be reported monthly to the Civil Auditor or Military Auditor General.

I am directed to acknowledge the receipt of your letter No. 2173, dated the 21st ultimo, on the subject of notices of leave of absence granted to Uncovenanted Servants sent to your office.

2. It appears that your office makes deductions on account of leave of absence only from the salaries of those Uncovenanted Servants who receive their appointments direct from Government; but that in all cases in which Clerks and other ministerial officers are allowed leave of absence, the Head of the department or office in which they are employed is left to make the deductions, your office simply passing the salary abstract of such Establishment without taking cognizance of the deductions made therein by the Head of the department or office, provided the Rule laid down in the Financial Resolution of the 18th December, 1843, is not infringed.

3. In reply, I am desired to inform you, that the Right Hon'ble the Governor General in Council is of opinion that the practice of your office is incorrect. The Rules of the 22nd February, 1856, he observes, are applicable to "all officers in the Uncovenanted Service of the Govt. who may be in the receipt of salaries of Rupees 100 a month and upwards" and it seems to His Lordship in Council that your office ought invariably to make the deductions provided for in the Rules, in every case in which leave is granted to such officers under the Rules, whether it be granted by Govt., or by officers to whom power to act upon the Rules may have been delegated by Government.

4. In respect to officers drawing salaries of less than Rupees 100 a month, it has been ruled, in the Financial Resolution of the 6th February, 1857, that the Heads of offices should, in granting leave, be guided by the spirit of the Rules prescribed for those servants who are in the receipt of salaries of Rs. 100 a month and upwards, and that all cases in which leave is so granted to Uncovenanted Servants whose salaries are less than Rs. 100 per month, shall be reported to the Civil Auditor and the Military Auditor General respectively, in the manner prescribed in the orders of the 25th July last; viz. that the Auditors should be furnished, on the 1st May in each year, with "An Annual Return showing the leave of absence granted during the year (preceding,) under the new Uncovenanted Civil Service Absentee Rules, to those Uncovenanted Servants whose leave might not have been notified in the Gazette."

5. But this arrangement seems to His Lordship in Council to be insufficient. It does not provide, as it ought to do, for deductions from salary by the offices of Audit, and His Lordship in Council therefore directs that in future all cases in which leave not notified in the Government Gazette is granted to Uncovenanted Servants in excess of the few days provided for in the Financial Resolution, No. 2520, dated the 12th June, 1857, shall be reported monthly (instead of annually) to the Civil Auditor or the Military Auditor General, as the case may be, in the form

the amounts entered in the form at the time the Establishment Bills are sent in to be passed, on the understanding that deductions are invariably to be made, in accordance with the Rules, from the pay of all Absentees whose names are entered in the form (whether they may be in the receipt of Rs. 100 a month), or less except when special directions are issued by the Heads of offices to make larger deductions, which may be necessary in cases of officers drawing less than Rs. 100, whose duties cannot otherwise be provided for without extra expense to Government.

I have the honor to be,
Sir,
Your most obedient Servant,
(Signed) C. H. LUSHINGTON,
Secy. to the Govt. of India.

Council Chamber, the 9th Novr. 1857.

Monthly Statement of Leave of Absence granted to Uncovenanted Servants drawing more than Rupees 10 per Mensem for the Month of 185 .

Name of Absentee.	Office held by Absentee.	Monthly Salary of Absentee.	Section of Rules under which Leave is granted or nature of Leave.	Period of Leave.	Amount of deduction from salary.	Name of substitute (if any).	Amount payable to substitute.	Net amount to be retrenched from Pay Abstract for the above months.	Remarks.
A. B.	Head Asst.	600 0 0	Section V. Chap. II.	Nine months from 1st Jany. to 30th September, 1859.	300 0 0	E. F.	300 0 0	0 0 0	
C. D.	5th ,,	200 0 0	Section VII. Chap. III.	Fifteen days, from 1st to 15th March, 1859.	000 0 0	None	0 0 0	0 0 0	
G. H.	21st ,,	60 0 0	Private Affairs.	Five months from 1st Jany. to 31st May, 1859.	30 0 0	L. M.	30 0 0	0 0 0	
O. P.	30th ,,	20 0 0	Ditto ,,	Ditto ditto	20 0 0	X. Y.	20 0 0	0 0 0	No substitute procurable on less than whole pay.
Y. Z.	Moonshee ,,	40 0 0	Sick Leave.	One month viz. March, 1859.	20 0 0	None	0 0 0	20 0 0	
								Total, 20 0 0	

No. 1.

Fort William, Financial Department, the 8th January, 1858.

Notification.—Read an endorsement from the Home Dept. No. 2,630, dated the 6th ultimo, forwarding for consideration and orders, a letter No. 1668, dated the 25th November last, from the Chief Secretary to the Govt. of Fort St. George, with its enclosures, referring for decision certain points connected with Privilege Leave to Uncovenanted Civil Servants.

1, 2 and 3 months privilege leave can be granted in accumulation for Service also prior to the issue of the new Rules.

Resolution.—With reference to that part of the Financial Notification dated 27th June last, No. 25, which provides for the cumulation of Privilege Leave to Uncovenanted Civil Servants, the Govt. of Madras submits an enquiry from the Civil Auditor, whether the cumulation is to have retrospective effect so as to admit of the period a party may have been uninterruptedly at his duties prior to the promulgation of the Uncovenanted Service Absentee Rules, to reckon as part of the period necessary to qualify him for obtaining cumulative leave; and if so, the date from which such effect is to be given.

Referring to this enquiry, the Right Hon'ble the Govr. Genl. in Council is pleased to decide that if Heads of offices certify that parties applying for accumulated privilege leave have served the requisite period uninterruptedly, there is no objection to applying to the Uncovenanted Service Rule which was passed in respect to the Covenanted Civil Service and approved by the Hon'ble Court viz. that service before as well as after the introduction of the new Rules is admissible in qualifying a servant for 1, 2 or 3 months privilege leave.

Vide Calcutta Gazette page 90, of 16th January, 1858.

No. 4.

Fort William, Financial Department, the 22nd January, 1858.

Relative to leave to be granted to Uncovenanted Servants prior to, and after the expiration of furlough on private affairs.

Notification.—Read again the following papers:—Extract Public Works, Dept. No. 1,443, dated 27th March, 1857, with its enclosure.

Read an office memo. No. 6196, dated the 30th ultimo, from the Public Works Dept. with its enclosure relative to the salary to be passed to an Uncovenanted Servant from the date of his return from furlough up to the date of joining his appointment.

Resolution.—On the 21st August, 1856, Mr. T. Login, Executive officer, Bassein River, obtained, under Section VII.* Clause 3 of the Uncovenanted Service Absentee Rules, leave of absence to Europe for a period of six months. He was subsequently allowed by the Hon'ble Court as a special case, nine months' leave of absence without pay, in addition to the six months already taken, thereby extending to fifteen months the whole period of his authorized absence from India, and which period, the Hon'ble Court directed, was to be regarded as if authorized under Section VIII.† of the above rules.

Mr. Login, having returned from England on the 31st October last, the Officiating Chief Engineer L. Ps. solicits orders regarding the salary to be passed to him from that date up to the 28th November last, the date of his arrival at Purneah, the Head Quarters of the division (Darjeeling Road) to which he is now attached.

The Offg. Secy. in the P. W. D. suggests the expediency of laying down general rules (if such rules do not already exist) to meet the cases of Uncovenanted Officers, who like Mr. Login, may not join appointments immediately on return from furlough.

Referring to this suggestion, His Lordship in Council remarks, that leave may be granted to Uncovenanted Servants preparatory to furlough on private affairs, or for return to station after the expiration of furlough, only on the terms of Section VIII.‡ of the

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* Now altered to Section VIII. † Now altered to Section IX.

‡ Now altered to Section IX.

Uncovenanted Civil Service Absentee Rules for the period specified in the Financial Notification of 14th October, 1857, viz. from six or eight weeks, according as the distance to be travelled shall not exceed 300 or 600 miles without forfeiture of appointment, but without pay, the period of absence not counting as service towards pension.

If the furlough, however, be enjoyed in India, no preparatory leave is to be granted; the furlough being reckoned from the date of the Absentee's quitting his post to the date of his return thereto.

MISCELLANEOUS INFORMATION.

To find the solid contents of semi-circular Roofs.

Rule.—Find the area, take the difference between the external and internal diameters or multiply the sum of the diameters by their difference and the product by ·7854 which divided by 2, will give the area.

When the area is found, multiply it by the length of the roof, including the masonry of the roof in the walls and the product will be the solid contents.

Example.—Find the contents of a vaulted roof 18 feet by 40 feet—roof 1 foot thick.

$$18 + 20 = 38 \times 2 \times \cdot 7854 \times 42 \div 2 = 1253 \cdot 4934.$$

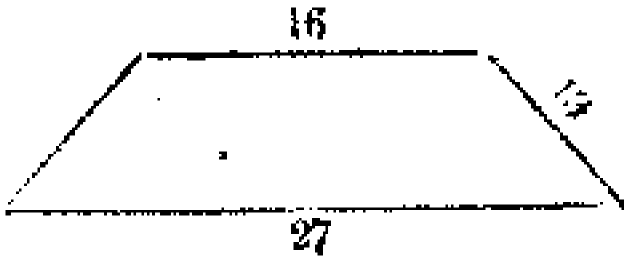
Bk. Master's Asst. III.

To obtain the contents of the concavity of an elliptic *vaulted* roof.

Rule.—Multiply the length of the vault by the area of one end.

To ascertain the quantity of thatching or tiling in a sloped roof.

Rule.—The length of the top ridge to be added to the length of the base and multiplied by the slant ½ of which will give the area of the roof for one side.



* 27 + 3 for eaves = 30

$$* \frac{30 + 16}{2} \times 13 = \frac{46}{2} \times 13 = 23 \times 13 = 299 \textit{ Answer.}$$

☞ Breadth and slope how ascertained when not given—viz. By deducting the height of the lower wall from that of the higher and adding the squares of both and extracting the square root of the sum (vide Prob. III. page 115.)

$$\begin{array}{rr} 16 - 9 = & 7 \\ \text{then } 7^2 = & 49 \\ 6^2 = & 36 \\ \hline \end{array}$$

$$\sqrt[2]{85} = \underline{9' \; 2''}$$

Prevention of dry rot from timber, consists in the simple submersion of the timber for about a week in a solution of corrosive sublimate.

MARCHING EXPENSES.

To cover extra marching expenses, an addition of one half to the gross pay or salary of all writers and other assistants proceeding on duty to the Upper Provinces, whose ordinary salaries do not exceed 200 Rs. per month, inclusive of the Military pay which any of them may be in receipt of, is granted from the day of the offices to which they shall be attached quitting the Presidency, until the day of their return inclusive. If the ordinary allowance exceed the above sum, one third in addition, is only allowed.

The above extra allowances are admissible also in cases where

Uncovenanted Assistants and others are entertained in the Upper Provinces to fill up vacancies or otherwise.

Pay and Audit Reg. 1849,
Page 240, *approved in G. O. G. G. 2nd June,* 1849.

TABLE MONEY TO BE CHARGED ON GOVERNMENT SEA-GOING VESSELS, &c.

No. 487.

Fort William, Home Department, the 14*th March,* 1856.

Notification.—The Right Hon'ble the Governor General of India in Council is pleased, in supersession of former orders, to establish the following rates of Table money to be charged on board Government Sea-going vessels employed under the Bengal Presidency, and on board the vessels of the Irrawaddy Flotilla.

For every adult Cabin or Quarter Deck Passenger, the Commander of the vessel, or the officer charged with the purveyance of the vessel, is allowed to charge the sum of four (4) Rupees a day.

For every child above 7, and under 14 years of age, who does not come to the table, the sum of two (2) Rupees a day.

For every child under 7 years of age, and for every Christian servant, the sum of one (1) Rupee a day.

No charge is to be made for children in arms.

The above named charges do not include Wine, Beer, Spirits, or Soda Water, or Refreshments required at other than the ordinary meal times. These must be paid for separately by those who may order them.

For European commissioned officers, of whatever rank, and Uncovenanted Civil officers, (not being of the rank of Clerks) when ordered a free passage on duty, the sum of four (4) Rupees each per diem will be allowed by Government to the Commander of the vessel, or to the officer of the vessel by whom they may be messed; but the whole expense of messing the families of such officers will be borne by the officers themselves.

Of the four (4) Rupees allowed by Government, the following proportions will be recovered from the officers through the Pay Department on account of Government.

From General officers,	Rs.	2	8	0	per diem.
From Field officers, and from Military and Medical and Uncovenanted officers (not being of the rank of Clerks) in Civil employ, on salaries not exceeding Rs. 600 a month,		2	0	0	,, ,,
From Captains,		1	0	0	,, ,,

The whole of the Table money charge (Rs. 4 a day) for subalterns will be borne by the Government.

The whole of the Table money charge for Military, Medical, and Uncovenanted officers in Civil employ, or salaries exceeding Rupees 600 a month, will be recovered from those officers on account of Government.

For persons messed at the warrant officer's or Engineer's Table, the following rates are allowed.

For Adults,	Rs.	2	0	0	per diem.
For children above 7, but under 14 years, each,		1	8	0	,, ,,
For children under 7 years old, each,		1	0	0	,, ,,

No charge is to be made for a child in arms.

The above charge for warrant officers of every grade, overseers, European Non-Commissioned officers attached to Departments or public offices, and Clerks of Departments or public offices, and for the families of any of these classes, will be paid by the Government.

These rules will be in force from and after the 1st proximo.

By order of the Right Hon'ble the Governor General of India in Council.

ORDERS OF THE HON'BLE THE COURT OF DIRECTORS RELATIVE TO THE DISMISSAL OF UNCOVENANTED SERVANTS.

Financial Department.

No. 42 of 1851.

Our Governor General of India in Council.

1st. We are informed by your letter dated the 7th February last, No. 9, that upon a representation from the Lieutenant-Governor of the North Western Provinces, enclosing communications from the Sudder Court and the Sudder Board of Revenue, you have suspended the carrying out of the instructions contained in Para. 19 of your despatch in this department dated the 10th July, 1850, to the effect that Uncovenanted Servants who have been dismissed from one department of the Public Service shall not be re-employed in another department.

2nd. It is necessary that we should briefly revert to the circumstances, in connection with which this instruction was given. Kessubnauth Ghose was in 1845 dismissed from his situation in the office of the Collector of Hooghly, because he was considered to be implicated in certain stamp frauds. The sentence of dismissal was confirmed by the Commissioner of the district, who however certified in the following year that he considered Kessubnauth eligible for another employment under Government. He (Kessubnauth Ghose) was accordingly appointed to a situation in the Civil Auditor's office, we animadverted upon the inconsistency of permitting a person who had been dismissed for moral delinquency to re-enter the service of Government, and concluded with the following remarks. " We consider it so injurious to the service that men who have been dismissed for misconduct from one department should be considered eligible for employment in any other department, that we must entirely discountenance such a practice. It is a wholesome check upon negligence and dishonesty for the servants of Government clearly to understand that probity and diligence are the only means of retaining employment under Government."

3rd. We should have imagined that a proposition based on so sound a principle unobjectionable; yet various objections have been raised to it. The Register of the Sudder Court North Western Provinces observes, that the Rule which we prescribed would be justly applicable to such persons as had been dismissed on conviction before a judicial tribunal of malversation, or any other offence which implies moral turpitude; that it would be applicable also "with less strictness to men who had been dismissed by their immediate superiors on strong presumption of malversation in those cases in which the order of dismissal had been upheld in appeal by the Appellate Authority, but that in other cases the rule would be apt to operate with unjust severity. The Sudder Board do not think that mere faults of negligence should be visited with so extreme a penalty, or even that the first dismissal for graver misconduct should necessarily be final, since the offence may have been wrongly imputed or may be adequately punished by temporary exclusion from office, and since the offender may subsequently redeem the good character which he has forfeited."

4th. In the letter from the Secretary to the Sudder Board of Revenue North Western Provinces, conveying the opinions of the Members of that Board. We notice the following passages:—"It scarcely needs to be stated that native officers are frequently dismissed from their situations not from proved delinquency or any tangible matter or substantial charge, but in accordance with the opinions of their immediate superiors taken up against them sometimes hastily. A large portion of the Public Servants are under the absolute control of one officer, who has the absolute power of dismissal, and men are consequently often dismissed by caprice, and also as a punishment." "An officer often too dismisses a man merely as a punishment with the intention frequently carried out of re-appointing him." Further, "the Native Servants of Government are treated with a degree of hardship which stands in remarkable contrast to the conduct adopted towards Europeans or Officers of mixed Parentage."

"To such an extent does this severity prevail, that all prudent natives resign, when they perceive that their superiors do not regard them with favor. This state of things has the worst effect on our Native Officers. It induces them to make hay while the sun shines; and to add to the severity now used by pronouncing every man dismissed incapable of serving Government would only add to the evil." Once again the Junior Member of the Board "takes this opportunity to put on record his deliberate opinion that less caprice, less severity, less indignity in the treatment of Native Servants of Government is necessary, if Government would be well served by them."

5th. We confess we have perused these statements with pain and deep regret. If the treatment of native officials by their covenanted superiors be indeed generally of the harsh character here alleged, it is most discreditable to those Members of our Civil Service who have practised it.

6th. But the rule we instructed you to introduce, in place of aggravating the evil as is alleged, will, in reality, ameliorate the position of the Uncovenanted Servants. We would establish it as a principle that when persons are appointed to permanent situations in any Department they should not be dismissed upon light grounds. Fraud and dishonesty, continued and wilful negligence, and all offences involving moral disgrace, meet with their appropriate punishment in dismissal; and our position is, that in every case in which that punishment is inflicted upon just grounds, the individual should be considered to be permanently excluded from Government employ. With regard, however, to the instances of arbitrary dismissal for slight reasons adverted to by the Secretary to the Board of Revenue, we can neither recognize their propriety nor see the advantage accruing to Government from the practice. It may be doubtful whether the punishment of temporary suspension, under the name of "dismissal with the intention of re-appointment," has any beneficial operation as regards the supposed offender. But we cannot doubt that it must tend to impede the business of the office by raising fears in the minds of the other native officials, that the caprice of their superiors may inflict upon them the same penalty. We consider it more likely that Government will be well served, if it is distinctly understood that probity and diligence are the conditions of continued employment, than if the subordinates work in slavish dread of their official superior, knowing that his whim, prejudice or passion may at any hour eject them from their situation and reduce them to destitution. In our opinion moreover, the knowledge that gross misconduct will altogether exclude from the service of Government will operate as an additional inducement to the honest and attentive discharge of duty on the part of Native Servants. If the offence which a subordinate may commit be considered by the chief of his office to merit severe punishment, though not the ultimate one of dismissal, the circumstances should be reported to higher authority, and if necessary, to the Government for their judgment and decision.

7th. The salutary tendency of the proposed rule will therefore be to make subordinates more faithful in discharge of their duties, and superiors more cautious in inflicting punishment upon those under their control. Necessary as it is that the power of dismissal should be vested in the Chiefs of Departments, it is equally desirable to check, and, as far as may be practicable, to regulate that power. If evidence of this be required, the letter from the Agra Board of Revenue affords it, and we shall here further quote the sentiments of the Junior Member of that Board as a corroboration of the view which we are led to take of this question. He observes that since he has entered the service "the Government have done much to temper the arbitrary severity with which their Native Officers are treated by their European fellow servants, and have, in consequence, materially increased the honesty and faithfulness of that deserving class of men; but more remains to be done, and he doubts not it will be done by degrees." We give due weight to the opinions to which we have adverted, and under the explanation we have given, we are not disposed to depart from our order of the 10th July, 1850.

8th. There is however a class of cases which does not come within the intention of our order, though erroneously considered in this light by the authorities in the North Western Provinces. We mean cases of inaptitude for the particular branch of occupation to which a Native Servant may have been originally appointed, as well as cases of physical incapacity. The latter must be treated according to rule; and with regard to the former, we cannot but think that in the majority of cases the difficulty might be overcome by a re-adjustment of duties without recourse to the harsh steps of removal from office.

9th. We should, in conclusion, express our hope that the notice we have taken of this subject will have the beneficial effect of inducing the exercise of greater forbearance and a more just consideration on the part of our Civil Servants towards the useful and deserving class of men placed in subordination to them. With respect to the most important class of those men, namely those receiving salaries of above 10 rupees a month, and to some of whom under certain restrictions, pensions are granted upon retirement, we think that you might issue instructions that you should be kept advised of the dismissal of all individuals composing that class, and of the causes of their dismissal. This would afford an opportunity for enquiry into cases in which the cause might appear unsatisfactory or questionable, which does not at present exist. Should any instances unfortunately occur to disappoint the expectation which we have expressed that greater forbearance and justice will be exercised towards the Native Servants, we desire to be invariably informed of them, whether they shall occur in the class above referred to or in any other, and we shall feel it to be our duty to visit such conduct with the expression of our severe displeasure.

We are &c.,

(Sd.) J. W. Hogg, and

Twelve other Directors.

London, 6th August, 1851.

RULES AND REGULATIONS D. P. W.

List of grades and appointments in the Department of Public Works with the salaries attached thereto as sanctioned by the Supreme Government of India.

Names of Appointments.	Salaries per Mensem.	
	Mily. Officers in addition to full Regtl. Pay and Allowances.	Persons not in the Mily. Service.
ENGINEER ESTABLISHMENT.		
Chief Engineer, 1st Class,	2,250 with pay proper only.	2,250
G. O. G. G. No. 112 of 17th July, 1857. Chief Engineer, 2nd Class and Supt. of Canals, N. W. Provinces,	1,000	1,400
Chief Engineer, 3rd Class,*	800	1,200
Assistant to a Chief Engineer,	500	750
Superintendent of a Work of more than one Executive charge,	600 to 800	900 to 1,200
Civil Architect at the Presidency,	700	1,000
1st Class Executive Engineer,	600	900
2nd Class, „	500	750
3rd Class, „	400	600
†4th Class, „	300	500 consolidated salary.
Assistant Engineers, 1st Class, Staff Salary,	250	350
Assistant Engineers, 2nd Class, „	200	250
Probationary Assistant Engineers,	112	100 to 200
UPPER SUBORDINATE ESTABLISHMENT.		
Sub-Engineer, 1st Class,	250	400
„ 2nd Class,	200	300
„ 3rd Class,	150	250
Supervisor,	120	200
Assistant Supervisor,	100	150
Overseer,	85	100
Assistant Overseer,	70	80
Probationary Ditto,	50	60
LOWER SUBORDINATE ESTABLISHMENT.		
Sub-Overseer, 1st Class.		
Deserving men above 10 years' service,		60
Ditto ditto above 5 years' service,		50
All others,		40
Sub-Overseer, 2nd Class.		
Deserving men above 10 years' service,		35
Ditto ditto above 5 years' ditto,		30
All others,		25
Sub-Overseer, 3rd Class.		
Deserving men above 10 years service,		25
Ditto ditto above 5 years ditto,		20
All others,		15
Sub-Surveyors,	As. Sub-Overseer.	1st and 2nd Class.
Cashiers according to charge,		20 to 50
Store Keepers, Ditto,		8 to 30
Head Artificer's Ditto,		8 to 15

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* The Superintending Engineers, Superintendent of Embankments, Bengal, and Superintendent of Canals, Punjaub, belong to this rank and are entitled to draw the pay and allowances attached thereto.

N. B. Surveyors, Mechanical Engineers and foremen will be placed either in the Engineer or Upper Subordinate Establishments according to their qualifications and services.

☞ The above mentioned appointments shall be open to all qualified persons without distinction, except so far as may be necessary to ensure the employment of all available Officers of the Engineer Corps.

Commissioned and Warrant Officers employed in the Department will be allowed their Mily. Pay and Allowances in full, and Non-commissioned Officers and Soldiers will be allowed their full pay and batta; but not clothing, bedding, &c. nor subsistence money for their wives and families. The Mily. Pay and Allowances of Commissioned, Warrant, and Non-commissioned Officers and Soldiers will be drawn from a Mily. Pay Office, under audit by the Military Auditors General; but in all except the Pay proper, will be debited to the Public Works accounts of the Presidency or Provinces in which each individual may be serving.

TRAVELLING ALLOWANCES TO OFFICERS OF THE ENGINEER ESTABLISHMENT.

I. No travelling allowance shall be granted in any case where an Officer does not proceed to a greater distance than five miles beyond the boundary of his station, or from his permanent or temporary Head Quarters or Standing Camp, except as provided in Rule III.

II. For travelling on public duty any distance not exceeding twenty miles in one day, Officers shall (subject to the limitation in Rule I.) be allowed as follows.

Chief Engineer Superintending Ditto	Rs. 6 per diem.
Executive Ditto and Assistant to Chief Engineer	Rs. 5 per diem.
Assistant Ditto	Rs. 4 per diem.

This allowance is to cover the expense of providing tents and other travelling Equipage.

III. The same allowance shall be passed to an Officer halting, and obliged to maintain his marching establishment complete, provided that, when within ten miles of his Permanent or Temporary Head quarters he does not halt for more than three days.

IV. For travelling on public duty any distance greater than twenty miles in one day, Officers shall (subject to the limitation in Rule 1st) be allowed eight annas per mile.

V. When an Officer makes a Dawk journey, leaving his Camp standing, he may draw allowances under both Rules III. & IV.

VI. In the case of Chief Engineers and Superintending Engineers, the travelling allowance shall be passed in Bills supported by Statements of the places visited with the date of arrival at, and departure from each, and of the distances travelled, with a certificate on honor that the journeys were made in the discharge of public duty.

VII. In the case of Ex. Engineers and Assistant Ex. Engineers, the charges shall be passed on the submission of journals showing, in addition to the particulars required in Rule VI., the object of each journey, the duties performed, and the results of the inspections made on each day; the journal bearing the countersignature of the Superintending Engineer in token of his belief that the journeys were properly undertaken in the performance of public duty, and in the case of Rule III. that marching establishment was necessarily maintained.

TRAVELLING ALLOWANCES TO THE OFFICERS OF THE SUBORDINATE ESTABLISHMENTS (IN ADDITION TO THEIR REGULAR DEPARTMENTAL SALARIES.)

I. A subordinate officer who is required to travel daily or frequently to a greater distance than he can easily do on foot, shall be allowed Horse Allowances at the rate of Rs. 15 per mensem, to be drawn on the Certificate of the Executive Engineer, that he is entitled to Horse Allowance under this Rule, and that a Horse or other means of travelling is kept.

II. Double Horse Allowance shall, on a similar Certificate, be allowed to any Subordinate Officer who is in charge of a Subdivision of a Road, Canal or Embankment.

III. Double Horse Allowance may also be granted under sanction of the Chief Engineer to a subordinate officer in any case in which Ordinary Horse Allowance is insufficient to cover the necessary expenses of travelling.

IV. Treble Horse Allowance may, under sanction of the Chief Engineer be allowed to a subordinate officer, employed in embankments during the rainy season, in any case in which Double Horse allowance is insufficient to cover the necessary expenses of travelling.

*V. The foregoing Rules are applicable to cases where buildings for shelter are provided, or where the subordinate officer is not required to proceed so far from his Head Quarters as to render the provision of shelter necessary.

VI. A Subordinate Officer performing duty which renders it necessary for him to keep up a tent and marching establishment shall, during the continuance of such duty, be allowed as follows.

Overseer and Assistant Overseer, ...	Rs. 1½	per diem.
Supervisor and Assistant Supervisor ...	Rs. 2	" "
Sub-Engineer,......	Rs. 3	" "

VII. This allowance is to cover all expenses of travelling; but an overseer or assistant overseer may, on the first occasion, be allowed a reasonable sum, as an advance for the purchase of a tent to be recovered by equal monthly deductions from his Salary for twelve months commencing three months after the payment of the advance.

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* The horse allowance admissible under Rules I to V can in no case be drawn along with the Tentage under Rule VI. and the latter can only be drawn when a Tent is actually kept and an Establishment for moving it maintained. G. O. P. W. D. No. 4245 of 28th August, 1857.

*VIII. A subordinate officer above the rank of overseer shall be allowed five annas per mile for all journeys exceeding twenty miles in one day made under the order of the Executive Engineer or those of a superior officer to the Executive Engineer.

IX. Under the same circumstances an overseer or assistant overseer, shall be allowed 2 annas per mile. But if ordered by the Chief Engineer to proceed by palkee or Carriage dawk, the dawk shall be laid by the Ex. Engineer, and charged in his accounts as a Contingent expense.

X. Subordinate officers, in progress to join appointments, (except when returning from leave) will be allowed travelling expenses under Rules VI. and VII. or VIII. and IX. according to the mode in which they may be directed to proceed.

☞ Sub-overseers and Sub-Surveyors, when employed on duties which render it necessary that they should travel often to the distance of 10 miles or more in one day, but having a fixed Head Quarters, and being provided with shelter when at a distance from their Head Quarters, shall receive a travelling allowance of 7½ Rs. per mensem. For journeys of upwards of 20 miles per diem, performed under the orders of the Executive Engineer or his Assistant, they shall be allowed an anna per mile. In every case these allowances will be admitted on the Certificate of the Executive Engineer.

LEAVE OF ABSENCE IN THE D. P. W.

All persons employed in the Public Works Department may be allowed one month's leave of absence in the calendar year without

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* The Mileage allowance under Rules VIII and IX may be drawn in addition to Horse Allowance or Tentage; but only for the distance travelled in excess of 20 Miles in one day and it is necessary that the subordinate shall have special sanction for the journey or journeys made exceeding 20 Miles in one day.

G. O. P. W. D., 28th August, 1857.

loss of salary, provided it can be granted without inconvenience to the Public Service. This leave may be granted by the Chief Engineer; but a Chief Engineer requiring leave must apply to the Local Government or to the Commissioner of the Province.

Leave of absence in excess of one Month, will be granted in the case of Commissioned, Warrant and Non-commissioned Officers and Soldiers under the Rules applicable to Milty. Officers in Civil employ,* and in other cases under the Rules applicable to the Uncovenanted Service (vide page 206.) This leave may be granted to all classes by the Governments of Madras and Bombay, and by the Local Administrations, subordinate to the Government of India, to all, except Commissioned Officers to whom leave must not be granted without the sanction of the Government of India.

* Excepting when these Rules are at variance with Rules specially applicable to Warrant and Non-commissioned Officers and Soldiers, in which case the special Rules will apply.

OFFICIATING APPOINTMENTS.

Salaries and Allowances Attached to.

A Military Officer officiating as Executive Engineer will, in all cases, be allowed a Staff Salary of Rupees 200 per mensem, with travelling allowance as an Executive Engineer. If Officiating as Assistant Engineer he will have the allowances of a Probationary Assistant Engineer.

An Assistant Engineer officiating as Executive Engineer, will be allowed Rupees 100 per mensem, with travelling allowances as an Executive Engineer, in addition to his salary as Assistant Engineer.

An Officer of the upper subordinate Establishment officiating as Assistant Engineer will be allowed 50 Rs. per mensem in addition to the allowances attached to his grade in the Subordinate Establishment.

An Officer of the upper subordinate grade holding Executive charge of a division will be allowed 100 Rs. per mensem in addition to the pay of his rank, drawing the travelling allowance of the grade in which he officiates, (Govt. Orders D. P. W. No. 2198 of 4th May, 1857.)

No person holding a superior appointment and officiating in an inferior one, will be allowed any additional salary, except in special cases under the sanction of the Government of India.

DUTIES OF AN EXECUTIVE AND ASSISTANT ENGINEER.

The duties of an Executive Engineer will be to manage the whole of the details of the Public Works under his charge including the provision of labour and materials, the payments of cash, and the tendering of accounts of all expenditure. He will be supplied with funds by letters of credit on the nearest Government Treasuries.

Those of Assistant Engineers employed under Ex. Engineers will be to render any general or special assistance that may be required, either by taking charge of a Sub-Division of works, or otherwise; Subject to the approval of the superintending and Chief Engineer. Assistant Engineers in charge of works of unusual importance, or who for other special reasons may have been allowed higher emoluments, will be termed Special Assistant Engineers.

DUTIES OF OFFICERS OF THE UPPER SUBORDINATE ESTABLISHMENT.

Will be employed in the immediate supervision of works or portions of works, or in conducting the departmental duties at small stations or posts, and sometimes in surveying and levelling, or other detached duties. Their Special duty will be executive supervision; and except in special cases, these Officers will not keep any public cash or have any thing to do with payments on account of public works, beyond granting cheques on cashiers, and seeing that artificers and laborers receive full payment at the prescribed periods.

Cashiers shall be appointed for the custody, payment and receipt of cash at all places where the disbursements are considerable. They will have no power to make payments except on the written order of the Executive Engineer, his Assistant, or of such Execu-

They will submit their accounts direct to Executive Engineers, supported by the orders duly receipted or pay lists witnessed by the Executive subordinate.

QUALIFICATIONS OF ASSISTANT OVERSEERS.

Assistant Overseers are required to have a good knowledge of Arithmetic, including mensuration and account-keeping, to know a little geometry, to be able to prepare simple drawings, to understand how to lay down and construct a building from drawings and specification, and to be able to prepare a simple estimate on being furnished with a design and the rates of work, and to survey with chain and compass and to take levels. Europeans must possess a fair Colloquial knowledge of the Native languages, and Natives must be able to speak and write English with tolerable accuracy.

QUALIFICATIONS OF SUB-OVERSEERS AND SUB-SURVEYORS.

Sub-overseers of the 3rd class must understand brick-laying, carpentry (including roofing and flooring,) road-making, and other work ordinarily done under departmental superintendence, so as to be able to direct workmen and turn out good work. They must also be able to write and keep accounts in English, unless when the Chief Engineer shall for special reasons dispense with this qualification.

Sub-overseers of the 2nd class must in addition to the acquirements expected of Sub-overseers of 3rd class, be able to lay down and construct in ordinary building from working drawings and specification—to prepare simple drawings, and to frame Estimates in English.

Sub-overseers of the 1st class must in addition to the above qualifications be able to survey with the chain and compass and to take levels.

Sub-Surveyors of the 2nd class must be able to survey with the chain and compass and to take levels.

Sub-Surveyors of the 1st Class must be able to make simple surveys with the theodolite in addition to the above.

☞ Persons capable of conducting all the practical operations of an ordinary survey with the theodolite and of plotting and preparing maps, which may be required for the service of the Public Works Department, will be entertained as assistant overseers for survey duties on the same footing in every respect except, in departmental qualifications as assistant overseers for general duties.

PARTIES DESIROUS OF ADMISSION INTO THE D. P. W. AS ASSISTANT OVERSEERS.

Soldiers serving with their corps, who desire admission into this grade of the department, will make their wishes known to their Commanding Officer, who, if there be no objection will, when in the vicinity of the College or School, arrange with the Principal for their being examined there.

In case of the candidate being at too great a distance from the College or School to be examined personally by the Principal, the Commanding Officer will apply to the College for Examination Papers which, on receipt, he will make over to the Executive Engineer of the district or his assistant (not being a Probationary Assistant) and arrange with that Officer to conduct the Examination. The Examining Officer will forward the Candidate's original answers and work, with such report as he may deem necessary, to the Principal of the College, by whom a Certificate will be granted or withheld, as he may judge to be right from the papers and report.

Having obtained the necessary certificate of the Candidate's qualifications, the Commanding Officer will transmit it, with the usual descriptive and character rolls, through the regular channel to the Army Head Quarters, whence, with the sanction of the Commander-in-Chief, the papers will be transferred for registry of the application to the Office of the Secretary to Government.

Civilians desirous of being appointed assistant overseers, should reside, who, on being satisfied that the candidate bears a good character, and appears likely to come up to the standard of qualification, and is not above twenty-five, or if a Sub-overseer of thirty years of age, will, in the first instance, send him to the Civil Surgeon, or to some other Government Medical Officer on the spot for examination. The Medical Officer being satisfied, as to the individual's physical fitness for employment, will furnish him with a certificate to the following effect.

"Certified that I have examined ——— and consider his eyesight to be good, and that he appears to be able to undergo the fatigues of active employment, as an Overseer in the Department of Public Works."

"Signed (A.,B. Surgeon.)"

On being presented with this certificate, the Executive Engineer will send the candidate to a Government College if there is one within a short distance, otherwise he will apply to the Principal of the nearest Government College for Examination Papers. The Examination will be conducted as above laid down for Soldiers; and on a certificate being obtained, the Executive Engineer will transmit it with the Medical Certificate and a Report, stating the residence, age and character of the candidate, through the Superintending to the Chief Engineer, by whom the Papers will be forwarded for registry in the Office of the Secretary to the Government of India.

Probationary Assistant Overseers will be expected to acquire a complete practical knowledge of the ordinary kinds of work required to be done under departmental supervision (see qualifications of Sub-overseers, 3rd Class) as well as such further practical knowledge of Engineering operations as they may have opportunity of acquiring. On completion of their probationary service (if not previously removed) the Probationary Assistant Overseers will be reported on by the Officers under whom they have been serving.

If satisfied with the conduct and qualifications of the Probationary Assistant Overseers, the Chief Engineer will recommend their permanent appointment to the Department; if not fully satisfied, he may order them to be kept on probation for any further period not exceeding one year; if he be of opinion that they are not qualified for permanent employment as assistant Overseers, he will recommend their being remanded to the Corps if Soldiers or discharged if Civilians.

Probationary Assistant Overseers, considered by Government deserving of permanent entertainment in the Department, will be gazetted as Assistant Overseers, from which date their standing on the list will reckon, and if Soldiers they will be brought on the Town Major's List.

PROBATIONARY ASSISTANT ENGINEERS.

Examination to be passed by Military Officers for the D. P. W.

The examination to be passed by Military Officers to render them eligible to be appointed Assistant Engineers on probation, will embrace Mensuration, Geometry, Algebra, Plane Trigonometry, Mechanics (including the general principles of the stability of Structures and strength of materials) Hydraulics, the nature and preparation of materials the ordinary practical rules of construction, and ability to frame ordinary designs and estimates, on being furnished with the rates of work as well as surveying with the theodolite, compass and chain, and levelling.

Candidates for examination, being Military Officers, must apply through the usual channel to the Officer commanding the station, who will arrange with the Principal of the nearest Government Civil Engineering College for the examination of the candidate if within a moderate distance, or for the supply of Examination Papers (to be delivered sealed to the Examiners) if the station be at a distance from the College. The Examiners shall be an Executive or Engineer Officer of standing and an Assistant Engineer (not on probation) or Subaltern Officer of Engineers, who shall meet at such time and place as may be sanctioned by the Commanding Officer of the station.

The report of the Examiners, with the candidate's original answers to the questions in the Examination Papers, shall be forwarded by the Examiners direct to the Principal of the College, who shall communicate the result of the Examination to the Commanding Officer of the Station, forwarding a Certificate if he be of opinion that the candidate has passed.

The certificate shall be transmitted to Army Head Quarters, in order that the qualification of the Officer might be notified in General Orders and recorded in the Army List.

PROBATIONARY ASSISTANT ENGINEERS WHENCE TO BE CHOSEN.

And Examination to be passed by Candidates who are not Commissioned Officers.

They are to be appointed from Officers of the Engineer Corps, from Officers of Artillery, Cavalry or Infantry of the E. I. C. S. or H. M.'s Regiments serving in India, and from deserving Individuals of the Upper Subordinate Establishment. From Civil Engineers sent out from Europe by the Court of Directors and from persons Europeans, East Indians or Natives who may have received Certificates of qualification and good conduct from the Government Colleges in India.

Certificates of qualification from Civil Engineering Institutions in Europe or America will also be admitted at the discretion of the Local Government as sufficient evidence of professional and educational qualification.

Candidates for employment as Probationary Assistant Engineers not being Commissioned Officers, must pass the Examination on professional subjects laid down for Commissioned Officers, must have a fair colloquial knowledge of the Hindustanee language and must also give proof that they have received a liberal education, to which end they must produce satisfactory evidence of having graduated at some recognized University, or must pass the examination laid down in G. O. P. C. No. 244 of 19th April, 1851; omitting the subject of fortification.

Gentlemen thoroughly acquainted with the theory and practice of surveying in all its branches, who may be required for service in the Public Works Department, will be entertained as Assistant

Engineers for survey duties under the same rules as Assistant Engineers for general duties except in regard to professional qualifications.

In all ordinary cases, Probationary Assistant Engineers will be examined as to their fitness for promotion to Assistant Engineer. If Engineer Officers, they must, before they can be examined have served one year in India. If not Engineer Officers, they must have served one year as Probationary Assistant Engineers. Every Probationary Assistant Engineer, before he can be examined for promotion, must be favorably reported on by his official Superiors. The examination which each will be required to undergo before he can be promoted, will be such as to shew that he is capable of preparing designs and Estimates for all descriptions of buildings and works usually required of Executive Engineers; that he is acquainted with the processes for preparing materials and with the modes of construction in use in India; that he has a good knowledge of the resources of the districts in which he may have been employed, as to materials and of the best mode of applying them; and that he understands the management of work people; also that he has made himself acquainted with the rules and understands the forms of account in use in the department.

This examination will be conducted by a Committee composed of one Superintending Engineer as president and two Executive Engineers or Engineer Officers of standing as Members. The record of the Committee's proceedings, with the Chief Engineer's observations and recommendation, will be submitted to the Government of India, by whom the appointment will be made. These Committees may be convened by Chief Engineers, on application for examination by candidates who have served the prescribed period, and are possessed of the preliminary qualifications.

The Rt. Hon'ble the Governor General in Council will in special cases dispense with the examination or reduce the period of service on probation.

SECURITIES.

The deposit of securities by Executive Engineers is not required under the new organization; but every person not in the Military Service nor under covenant to the Court of Directors must, before he can be permanently appointed to the Engineer establishment or upper subordinate establishment, furnish security to the amount of 2,000 Rs. in the former and of 400 Rs. in the latter, to be forfeited in the event of his leaving the departments without leave, or without giving two months' notice.

Vide G. O. G. G. No. 117 *of* 17*th June*, 1857.

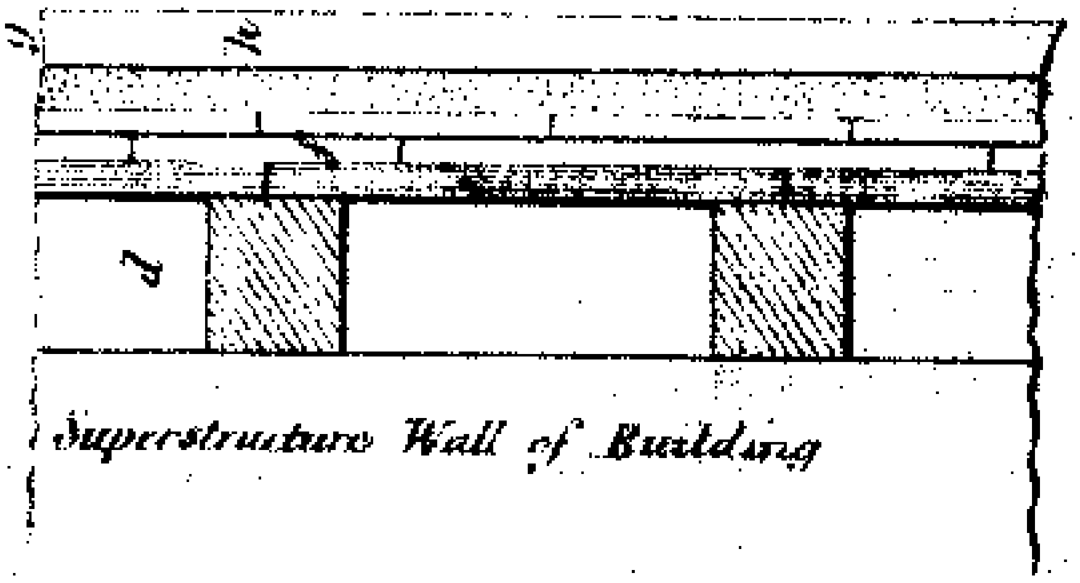
EXPLANATORY NOTES ON THE DRAWINGS. D.

In the ground Plan the out lines *c. c.* shew the edges of the Plinth Walls of the buildings as will be visible when raised above the foundation. The spaces filled in thus ▨ shew the Walls of the Superstructure raised on the Plinth Walls which latter are 3″ broader in each side than the Superstructure Walls (vide *Section* .)

The *Section* represents the Building (as it would appear to a person standing directly opposite it) if sliced off from A. to B. from top and the front portion removed.

The *d d.* in the *Section* shew the ends of the Beams and the *e. e.* shew the Rafters or Burgahs laid across the Beams over which Burgahs is the terrace over two tiles laid flat see following plan.

d. Beams,
e. Rafters,
f. Two Layer of Tiles,
g. Terrace,
h. Parapet Wall.



The *Elevation* does not need any particular description; as it plainly shews itself to be the *façade* or front view of the Building.

The scale twelve feet to an inch is made by drawing a straight line, and with the compasses taking the space of an inch from the

Ivory or Brass scale in the Instrument Box and then dividing the inch into twelve equal parts, each of which may be called a foot thus twelve feet to the inch, you may divide this inch into any number of equal parts according to the size of the Drawing that may be required. There are different scales required for different kinds of drawings which the new beginner will be able to understand hereafter.

METHOD OF FRAMING OR PREPARING AN ESTIMATE FROM A GIVEN DESIGN.

(vide Plan D.)

Thus: I wish to know what it will cost me to construct a range of out-offices of the dimensions noted on the accompanying plan; of kiln burnt bricks and mortar (the latter composed of ⅔rds Soorkey or brick-dust and ⅓rd lime) with a flat terraced roof resting on beams and burgahs or rafters; with three entrance doors 8 feet × 3½ feet each and 4 windows 2 feet square each.

	Put down first	No.		Length.		Breadth.		Height or Depth.		Total.
Then calculate thus	Long Walls i. e. North and South	2	×	33	×	2	×	2	=	264
	End Walls (East & West)	2	×	11	×	2	×	2	=	88
	Centre or Partition Walls.	2	×	11	×	2	×	2	=	88
	Total quantity of Cubic or Solid feet of Masonry in foundation									440

☞ Let us see how we came to find out that the length of each of the two Walls North and South is thirty-three feet: (vide Ground Plan) viz.

By adding up 8 + 8 + 12 = 28 the breadth of the rooms,
to which add...................... 4 ft. the breadth of the 4 Walls
and to this add again .... 1 ft. i.e. the projection, 3″ Plinth
and 3″ of foundation on each side

Total 33 feet

Next. To know how the length of the end and centre walls was found out: thus

The range of out-offices inside is twelve feet in breadth i. e. the space between the superstructure walls which are one foot in breadth ; consequently the Plinth Walls being thicker by ½ ft. and the foundation Walls by another ½ foot there will necessarily be a projection as clearly shewn in the *Section* of 3″ + 3″ = 6″ on each side of the superstructure Walls, therefore the foundation of the Centre and end Walls will by deducting the 6″ on each side (=1 foot for both sides) be eleven feet in length.

Having found out the quantity of Masonry in the foundation Walls, we will next proceed to the Plinth.

Calculate the same way as before.	No.		Length.		Breadth.		Height or Depth.		Total.
Long Walls N. and S.	2	×	32½	×	1½	×	1	=	97½
End Walls E. and W.	2	×	11½	×	1½	×	1	=	34½
Centre or Partition Walls	2	×	11½	×	1½	×	1	=	34½
Total quantity of Cubic or Solid feet in Plinth							166½		

The Length of the Plinth long Walls is found out in the same way as those of the foundations; ½ foot only being decreased i. e. 3″ on each side for the foundation already estimated.

The Length of the end and centre or partition Walls increases proportionately ½ foot as will be seen from the *Section*.

SUPERSTRUCTURE.

Calculate as before	No.		Length.		Breadth.		Height or Depth.		Total.
Long Walls	2	×	32	×	1	×	14*	=	896
End Walls	2	×	12	×	1	×	14*	=	336
Centre Walls	2	×	12	×	1	×	12.9†		306
Total Cubic feet of Masonry in Superstructure									1538

* These include parapet all round

† This is the height up to the Rafters.

DEDUCT OPENINGS.	No.	Length.	Breadth.	Depth.	Total	
Doorways	3 ×	8 ×	3½ ×	1 =	84	
Windows	4 ×	2 ×	2 ×	1 =	16	100
Total Cubic feet of Masonry in Superstructure						1438

Note—Contractors and builders generally do not in their Estimates give any deductions for openings, as the Masonry thus obtained, pays for the cost of the arched masonry over the Doorways, &c. which is more expensive than plain masonry.

Cornice all around	No.	Length.	
	2 ×	32 =	64
	2 ×	14 =	28

Total running feet of cornice 92

Roofing with two tiles, one laid flat above the other, with six inches of broken bricks and lime, &c. beaten into a terrace of four inches thick 30 × 12 = 360 Supfl. feet of roofing.

FLOORING	No.	Length.	Breadth.	
	2 ×	11½ ×	7½ =	172½
	1 ×	11½ ×	11½ =	132¼

Total Supfl. feet of flooring 304¾

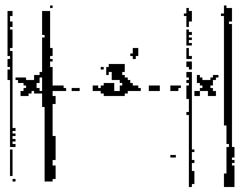
☞ For Flooring the space between the Plinth Walls is generally taken as above.

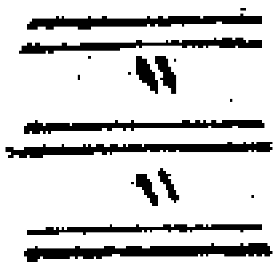
WOOD WORK.

Beams as	No.	Length.	
Shewn in Section	7 ×	14 =	98 running feet of Beams
Burgahs or Rafters	11 ×	9 for 2 rooms =	198
" "	11 ×	13 for larger Rooms =	143

Total 341 Running feet of burgahs 3″ + 2″

		Breadth.	
Doors	3 × 8 ×	3½ =	84 Supfl. feet of Doors ⅓ Panel
Windows	4 × 2 ×	2 =	16 Supfl. feet of Batten Windows

Notes.—Beams are generally placed apart three feet from centre to centre thus  burgahs one foot apart thus



Now for the Abstract of all the items, to find out the cost of the Building; assuming the rates of the several kinds of work: as follow.

		Rs.	Rs.	A.	P.
440	Cubic feet of Masonry in foundation including digging foundation	@ 9 per 100 feet.	39	9	7
166½	Cubic feet of Masonry in Plinth including plastering on one side	@ 10 per 100 feet.	16	10	4
1438	Cubic feet of Masonry in Superstructure including plastering	@ 13 per 100 feet.	186	15	0
360	Supl. feet of Roofing with two Tiles and 4″ beaten Terrace	@ 14 per 100 feet.	50	6	4
304¾	Supt. feet of flooring with brick on edge laid over 9″ thick khoah	@ 10 per 100 feet.	30	7	7
84	Supl. feet of ⅓d Panel and ⅔d Venetians-Doors including Chowkuts or Door-frames	@ 8 as. per foot	42	0	0
4	Batten Windows two feet square each	@ 2 each	8	0	0
92	Running feet of plain Cornice projecting 6″ inches	@ 2 as. per foot	11	8	0
98	Running feet of Beams 9″ × 6″	@ 4 as. per foot	24	8	0
341	Running feet of Burgahs or Rafter 3″ × 2″	@ 4rs. p 100 ft.	13	10	2
			423	11	0
	Contingencies generally allowed @ 5 per cent	……………………	21	2	11
		Grand Total, Company's Rupees	444	13	11

☞ N. B. Painting, &c. may be added by calculating the surfaces of the Doors and Windows on both sides and of portions of the Beams and Burgahs exposed to view.

DETAILED MEMO. OF THE COST OF BRICK MAKING AT MIDNAPORE.

Midnapore, June, 1858.

It has been ascertained that in the adjacent brick kilns 100,000 bricks 11½″ × 6″ × 2½″ cost as follows—

For moulding including clearing ground @ 8 annas per 1000,…………………………………………	50	0	0
1200 mds. of Wood including conveyance @ 6 Rs. per 100 mds. …………………………………………	72	0	0

Cutting or preparing wood for the kiln, ...Rs.	4	8	0
Paddy straw, ...	1	8	0
6 brick moulds complete @ 4 annas each, ...	1	8	0
3 mamooties or kodallies @ 1 Rupee each, ...	3	0	0
Preparing and arranging kiln, ...	25	0	0
Contingencies,...	2	0	0
Total Co.'s Rs.	159	8	0

Which is the highest cost for burning 100,000 bricks in this district where fuel is cheap; and deducting from this quantity 25,000 bad bricks, &c. leaves the rate at 2 Rs. 2 annas per 1000 at which 11½ inch bricks are procurable here.

ESTIMATE *showing the mode of calculating for the Construction of a flat-roofed Building, as per annexed Plan A.*

DETAIL OF BUILDING.	Number.	Length.	Breadth.	Height.	Total.	Solid feet of Pucca Masonry.	Ditto oneside Plaster.	Ditto with Plaster on both sides.	Supfl. feet of Roof, 2 Tiles and 6 inches, Terrace.	Ditto ditto 2 Tiles and 4 inches Terrace.	Supfl. feet of Floor laid Brick on edge with Tiles.	Running feet of Cornice.
Foundation.												
Long Walls, North & South, … …	2	73	2½	2	730							
End ditto East and West, … ……	2	48	2½	2	480							
Centre Room Walls, North & South,	2	40¼	3¼	2	523¼							
Ditto End ditto East and West, …	2	18¾	3¼	2	243¾							
Cross Walls, … … … … ……	5	13⅞	2½	2	346⅞							
Ditto ditto, … … … … …	2	8⅞	2½	2	$88\frac{6}{8}$							
Plinth.						2412⅝						
Long Walls, … … … … ……	2	72½	2	1	290							
End ditto, … … … … … …	2	48½	2	1	194							
Centre Room ditto, … … ……	2	39½	2½	1	197½							
Ditto End ditto, … … … …	2	19½	2½	1	97½							
Ditto ditto Cross Walls, … ……	5	14½	2	1	145							
Ditto ditto ditto, … … … …	2	9½	2	1	38							
Superstructure.						……	962					
Long Walls, … … … … ……	1	72	1½	16	1728							
Ditto ditto, … … … … … …	2	20	1½	16	960							
End ditto, … … … … … ……	2	49	1½	16	2352							

Centre Room Walls, ...	2	39	2	22½	3510							
Ditto ditto End ditto, ...	2	20	2	22½	1800							
Ditto Cross ditto, ...	5	15	1½	16	1800							
Ditto ditto ditto, ...	2	10	1½	16	480							
					12630							
Deduct *Openings*, (⅓rd.)												
Door-ways, ...	10	8½	4½	2	765							
Ditto, ...	12	8½	4½	1½	688½							
Ditto, ...	4	7½	3½	1½	157½							
					1611							
						......	...	12093				
Steps, South,...	1	19	3	1	57							
Ditto, ditto, ...	4	5	2	1	40							
Ditto, ditto, ...	2	5	1	1	10							
						......	107					
CALCULATION FOR THE ROOFS AND FLOORS.												
Roof of Centre Room, 2 tiles 6 inches Terrace Floor Brick on edge 15 inches Tiles, ...	1	35	20	1	700	......	...	......	700	......	700	
The Verandah Roofs, to be 2 Tiles and 4 inches Terrace Floor laid as above,												
(Carried over.)						2412⅝	1069	12093	700	....	700	...

ESTIMATE,—(*continued.*)

DETAIL OF BUILDING.	Number.	Length.	Breadth.	Height.	Total.	Solid feet of Pucca Masonry.	Ditto oneside Plaster.	Ditto with Plaster on both sides.	Supfl. feet of Roof 2 Tiles and 6 inches Terrace.	Ditto ditto 2 Tiles and 4 inches Terrace.	Supfl. feet of Floor laid Brick on edge with Tiles.	Running feet of Cornice.
(Brought forward,)	...	......	......	......	....	2412⅝	1069	12093	700	....	700	...
Roof b, ...	1	26½	15	1	397½							
Ditto *c,*	1	21	15	1	315							
Ditto *d,*	1	15	15	1	225							
Ditto *e,*	1	19	15	1	285							
Ditto *f,*	1	36	15	1	540							
Ditto *g,*	1	15	12	1	180							
Ditto *h,*	1	36	10	1	36							
					2302½							
						......	...	......	......	2302½	2302½	
Verandah Pillar, ...	6	12	1½	1½	162							
Walls above, (deducting Architrave,)	1	32	1½	3	144							
					306							
						......	...	306				
Terrace and Drains, ...	1	260	1	1½	1170	......	1170					
Running feet of Cornice projecting 9 *in.*	...	...	...	...	......	......	...	......	......	......	......	374
Total, ...	...	...	...	...	......	2412⅝	2239	12399	700	2302½	3002½	374

Summary or Abstract of the Detail.

2,412⅝	Solid feet of Masonry in Foundation,...	@	0/0 per	0/0 feet,						
2,239	Ditto ditto one side Plaster in Plinth, Steps, Terrace, Drain,	@	„	„						
1,2399	Ditto Plaster on both sides in Superstructure, ...	@	„	„						
700	Superficial feet, Roof 2, Tiles and 6 inches Terrace, ...	@	„	„						
2,302½	Ditto ditto 2 ditto and 4 inches ditto, ...	@	„	„						
3,002½	Ditto Floor laid Brick on edge, with 15 inches Tiles, ...	@	„	„						
9	Saul Beam 23 feet long 11¾ × 8 inches Scantling, ...	@	„	„						
32	Ditto ditto 18 feet ditto 10 × 6½ inches, ...	@	„	„						
14	Ditto ditto 13 feet ditto 8½ × 5 inches, ...	@	„	„						
32	Running feet ditto Architrave, 10 × 15 inches, ...	@	„	„						
3,002½	Ditto ditto Burgahs, ...	@	„	„						
14	Tiled revolving Glass Windows, to be painted green, 2 Pairs 6 × 1 foot 6 inches, ...	@	„	„						
80	Running feet of 4 feet Saul Railing, with gates and Hinges,	@	„	„						
22	Teak Venetian Doors with Saul Chowkuts 8½ × 4½ including Hinges, Bolts, &c., ...	@	„	„						

Summary or Abstract of the Detail,—(continued.)

4	Saul Panel Doors with ditto ditto 7½ × 3½ feet, including ditto, ...	0/0 per 0/0 feet, @ ,, ,,						
4,655	Superficial feet White Painting, ...	@ ,, ,,						
2,331	Ditto Green ditto,...	@ ,, ,,						
24	Water-spouts, ...	@ ,, ,,						
	Classies and Coolies for raising Beams, Burgahs, &c., ...							
	Carpenters for fixing Doors, &c.,...							
	Carriage for Wood-work, ...							
374	Running feet of Cornice projecting 9 inches, ...							
			——	—	—	0000	0	0
	Add Contingencies @ 5 per cent., ...		...	...	...	000	0	0
	Total, Company's Rupees, ...					0000	0	0

N. B.—The above mode of Calculation is applicable to all flat-roofed buildings, in order to know the probable expense of constructing the same.

ESTIMATE *showing the Calculations for the Construction of a Building with a Thatched Sloping Roof, or of a Bungalow.*—(Vide *Plan* B.)

Specification.—The Bungalow to be built of the best Pucca Masonry, with a Thatched Roof, Pucca Floor, Doors, and Windows: it will consist of 2 Rooms, 16 feet square, with a Verandah of 7 feet wide all round, with 2 Closets or Bathing Rooms at the 2 corners East and West, and 2 Dressing Rooms,—required the cost of the same.

DETAIL OF MEASUREMENTS.	Length.	Mean Height.	Breadth.	Total.	Grand Total.
Foundation.					
Long Walls, ... 4 × 54·5 = 218					
Cross ditto, ... 5 × 15 = 75					
Verandah ditto, ... 8 × 6 = 48	341	2·5	2·5	2,131·25	
Steps, ... 2 × 8 = 16					
" ... ... 4 × 10 = 40	56	2	0·5	168	
Total Masonry in Foundation, ... (Carried over,)	...	...	...	......	2,299·25

DETAIL OF MEASUREMENTS.		Length.	Mean Height.	Breadth.	Total.	Grand Total.
Plinth.	(Brought forward,)					2,299·25
Long Walls, ...	4 × 54 = 216					
Centre Cross ditto, ...	5 × 15½ = 77½					
Verandah ditto, ...	8 × 6½ = 52	345½	2	1·5	1,036·5	
Steps, ...	2 × 8 = 16					
" ...	2 × 6 = 12					
" ...	2 × 4 = 8					
" ...	4 × 10 = 40					
" ...	4 × 8 = 32					
" ...	4 × 6 = 24	132	2	0·5	132	
Total Masonry in Plinth, ...						1,168·5
Buttresses, ...	2 × 56·5 = 113 2 × 36·5 = 73	186	1	1	186	
Total Masonry in Buttresses, ...						186

Superstructure.							
Long Walls, … … … … … … …	2 × 53·5	= 107					
End ditto, … … … … … … … …	2 × 33	= 66	173	11	1½	2,854·5	
Verandah Cross ditto,… … … … … …	8 × 7	= 56	56	14½	1½	1,174·5	
Inner Long ditto, … … … … … …	2 × 36·5	= 73					
Cross Walls, … … … … … … …	2 × 16	= 32	105	18	1½	2,835	
Ditto ditto, … … … … … … … …	1 × 16	= 16	16	18½	1½	444	
Gable to ditto, … … … … … … …	1 × 19	= 19	19	4	1½	114	
						7,422	
Doorways.							
Doorways, … … … … …	8 × 8 × 4 × 1½	= 384					
” … … … … … …	2 × 7 × 4 × 1½	= 84					
Windows,… … … … … …	4 × 5 × 4 × 1½	= 120					
” … … … … … …	2 × 6 × 6 × 1½	= 108					
” … … … … … …	4 × 5 × 6 × 1½	= 180					
Spaces in Rear Verandah, … …	2 × 12½ × 11 × 1½	= 412·5					
Deduct ⅔rd for Doorways, &c. … … … … … …		= 859	…	…	…	859	6,563
							10,216·75

Detail of Measurements.	Length.	Mean height.	Breadth.	Total.	Grand Total.
Terrace Floorings.					
Flooring, … … … … 2 × 15·5 × 15·5 = 480·5					
” … … … … 4 × 15·5 = 62					
” … … … … 2 × 6·5 = 13					
” … … … … 2 × 24 = 48					
123 × 6·5 = 799·5					
				1,280	1,280
Roofing, … … … 2 × 56·5 × 2 × 25·5 = $\frac{5763}{2}$ = 2881·5					
Total Supfl. feet of Thatched Roofing, … … …	…	…	…	………	2,881·5
Doors.					
Venetian Doors, … … … … … 8 × 4 × 8 = 256					
2 × 4 × 7 = 56					
4 × 4 × 5 = 80					
392					
Total Supfl. feet of Venetian Doors, … … … …	…	…	…	………	392
Wall-Plates, … … … … … … 2 × 14·5 = 29					
Total Running feet of Wall-Plates, … … … …	…	…	…	………	29
Ceiling Cloth, … … … … … … 2 × 16 × 16 = 512					
Total Supfl. feet of Ceiling Cloth, … … … …	…	…	…	………	512
Floor Matting, … … … … … … 2 × 16 × 16 = 512					
Total Supfl. feet of Floor Matting, … … … …	…	…	…	………	512

ABSTRACT.

10,216·75 Solid feet of Pucca Masonry, ...	@ 0/0 per 0/0 feet,				
1,280 Supfl. „ Terrace Flooring, ...	@ „ „				
2,881·5 „ „ Thatched Roofing, ...	@ „ „				
392 „ „ Venetian Doors, ...	@ „ „				
29 Running feet of Wall-Plates, ...	@ „ „				
512 Supfl. „ Ceiling Cloth, ...	@ „ „				
512 „ „ Floor Matting, ...	@ „ „				
	Rupees, ...	0	0	0	0
	Total, Company's Rupees, ...	0	0	0	0

N. B.—The above mode of calculation is applicable to all Thatched Buildings, of the kind mentioned in the Specification.

Mode of framing an Estimate for the Construction of a Masonry Drain Bridge.—(Vide *Plan C.*)

MEASUREMENTS.	Number.	Length.	Breadth.	Height or Depth.	Total.	Grand Total.
Foundation :—						
Abutments, including Flooring, ...	0 ×	26 ×	14 ×	2	= 728	
Sunk Portions of Aprons, ...	2 ×	13 ×	3 ×	2	= 156	
Wing-Walls, ...	4 ×	7 ×	3 ×	2	= 168	
Superstructure :—						1,052
Abutments, ...	2 ×	25 ×	$2\frac{1}{2}$ ×	4	= 250	
Wing-Walls, ...	4 ×	7 ×	2 ×	$9\frac{1}{2}$	= 532	
						782
Spandrells, ...	2 ×	13 ×	2 +	$5\frac{1}{2}$	= 286	
(*By Problem X.* MENS. SUPERF.)						95·94
Deduct Arch $11^2 \times \frac{\cdot 7854}{2} = 47{\cdot}516 \times 2 \times 2$					= 190·06	
Parapet, ...	2 ×	27 ×	$1\frac{1}{4}$ +	4	=	324·
Arching,—11 + 8 = 19, sum of diameters × 3 *diff.*, 57 × $\frac{\cdot 7854}{2}$ = 22·3839 by						2,253·94

Prob. XIII. MENS. SUPERF. × 25 length of Arch, ... = 559·5975

ABSTRACT.

2253·94 cubic feet of Pucca Masonry.

559·5975 cubic feet of Pucca Arched Masonry.

NOTE.—The preceding Examples are intended to acquaint the Student with the mode in which Estimates for the construction of similar Buildings are made out, or *framed*, in the Department of Public Works. A person cannot, however, obtain any proficiency in the art of framing out intricate Estimates without the assistance of a master, or unless he practises for a considerable time in comparing and examining the details of already prepared Estimates with their respective Plans; but as all Estimates for Buildings of every description are *framed* by the Executive Engineers themselves from standard plans or designs of their own, this Work does not necessarily devolve on the Overseer,—nevertheless, it is highly requisite that an Overseer should understand the several details of the calculations, to enable him to supervise the construction of a Building efficiently.

An Overseer, however, after an experience of a year or two in this Department, generally makes himself acquainted with the mode of preparing Estimates, from the frequent opportunities he has of studying numerous Plans and Estimates in the Executive Engineer's Office, and from the instructions he receives from the Officer from time to time connected with his duties.

Likewise in drawing Plans a person cannot attain any proficiency without the assistance of a Master, or unless he practises for some time in copying from proper Books and Drawings: "Colonel Pasley's Practical Geometry" contains many clear and detailed Rules and Examples explanatory of the principles of Plan-drawing, from which the Student may learn a great deal on this head.

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ERRATA.

In page 10 examp. 2nd *for* $52\frac{2}{25}$ *read* $54\frac{12}{25}$.
„ 19 „ 9th *for* 4*s*. $3\frac{1}{5}$*d*. *read* 4*d*. $3\frac{1}{5}$*f*.
„ 21 „ 2nd *for* $\frac{2}{4800} = \frac{1}{2400}$ *read* $\frac{2}{6720} = \frac{1}{3360}$.
„ 188 „ 3rd line under "Materials" *for* Stone-lime *read* Ghooting Lime.
„ 197 „ 9th line *for* plan *read* post.

A

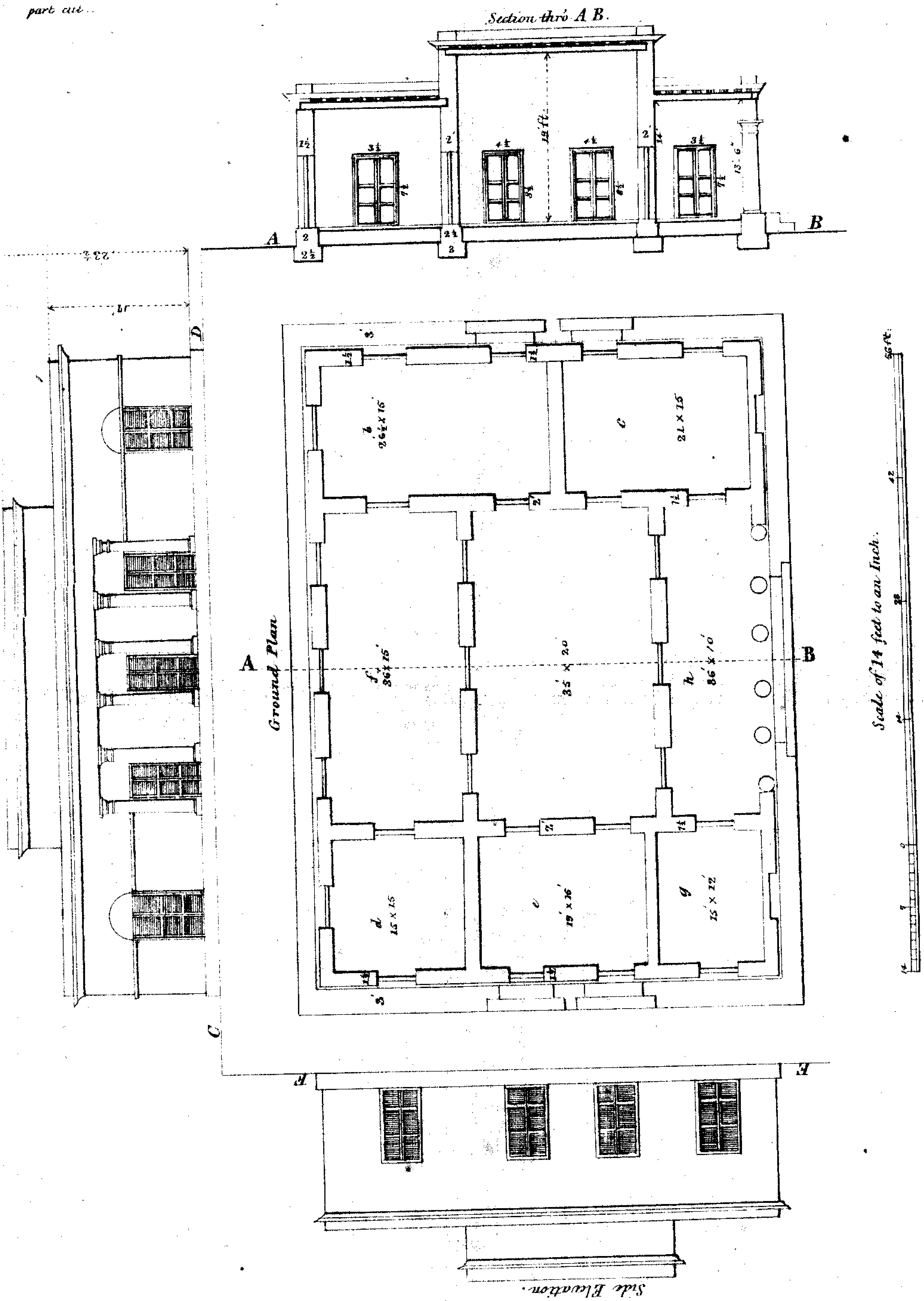
PLAN ELEVATION AND SECTION OF A PUCCA FLAT ROOFED BUILDING.

Definition

A "Plan" of any object is the appearance it would present if it could be viewed from a point above it.

"Elevation" Signifies the view of any upright side of a Building nearly such as it would appear to a person standing exactly in front of it.

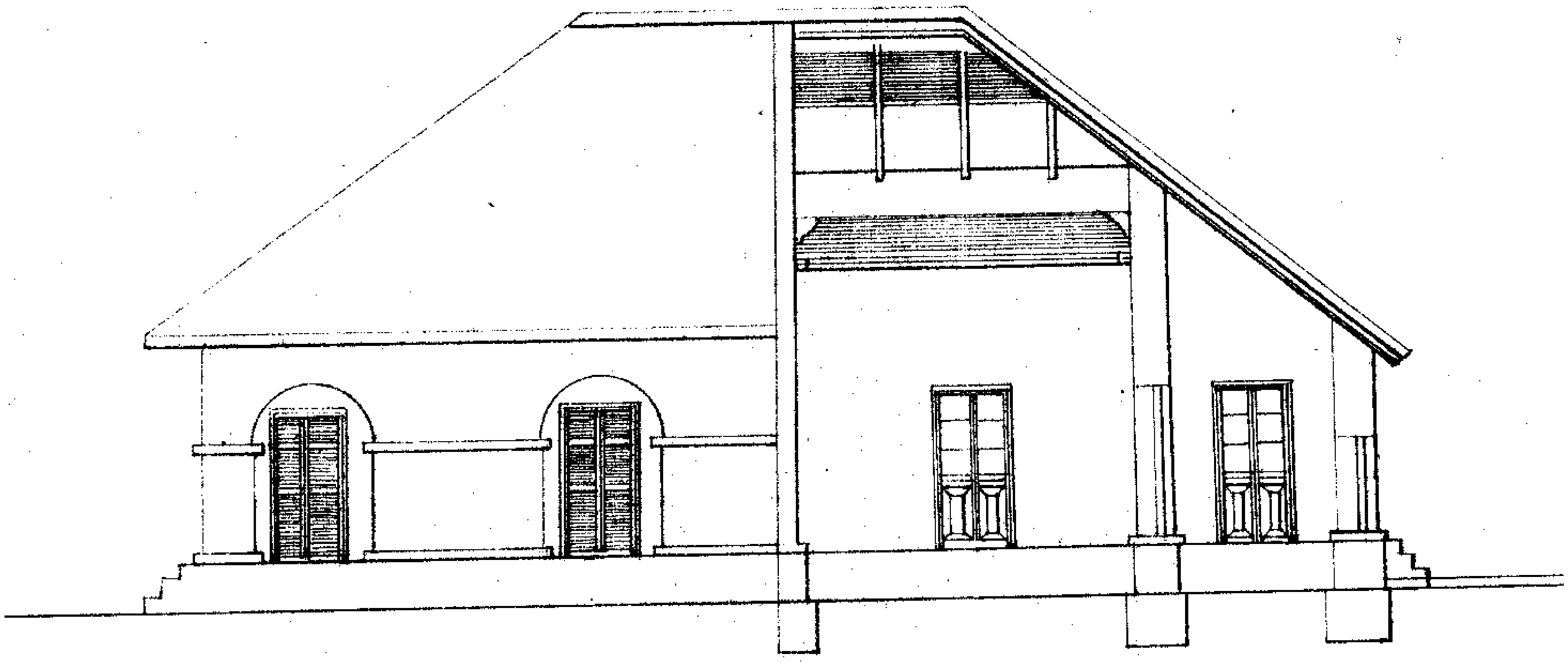
"Section" denotes the view that would be disclosed to one by cutting a solid figure right into two, of the part cut.



B.

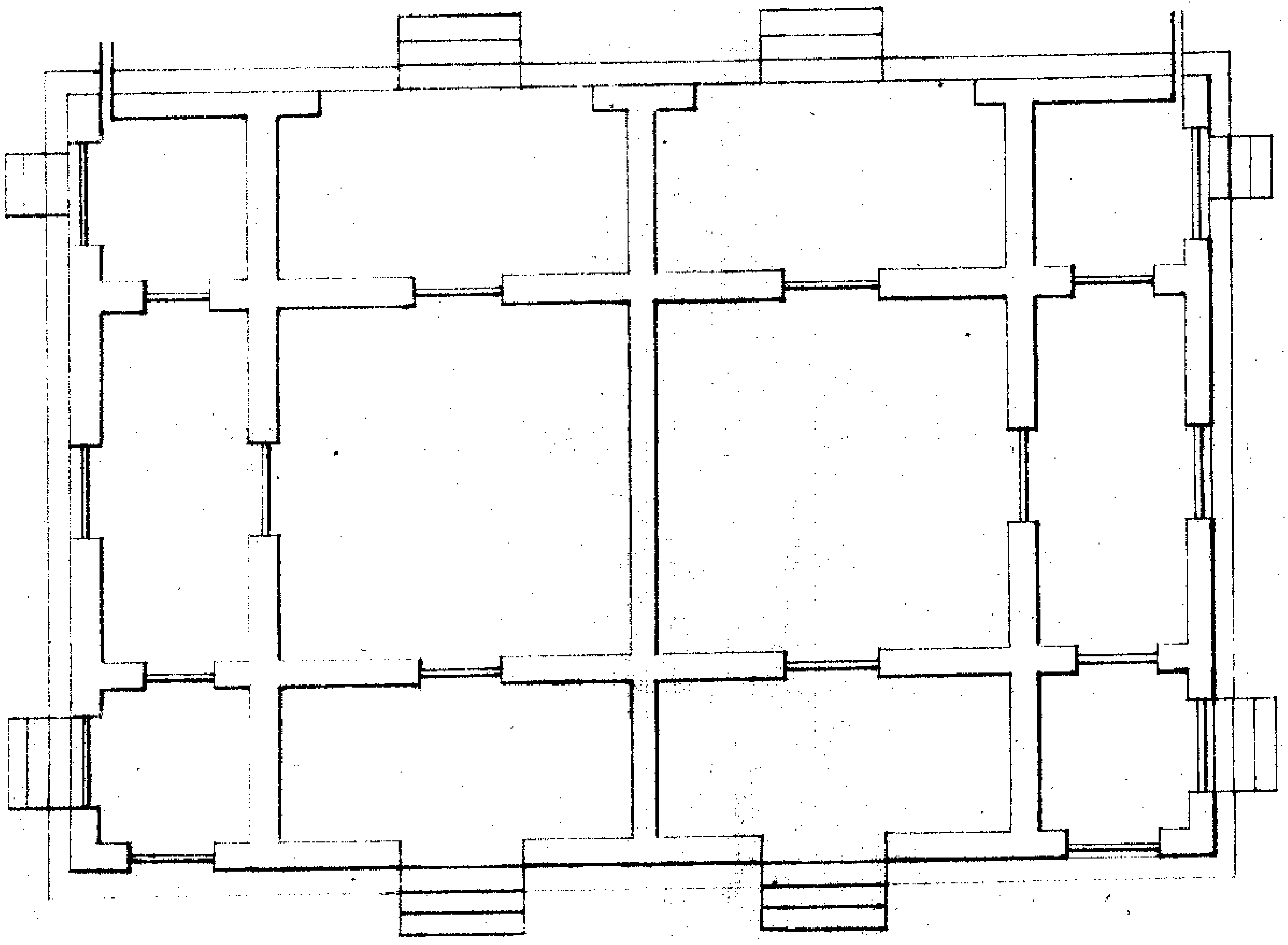
Plan, half Elevation & half Section.

of a Bungalow

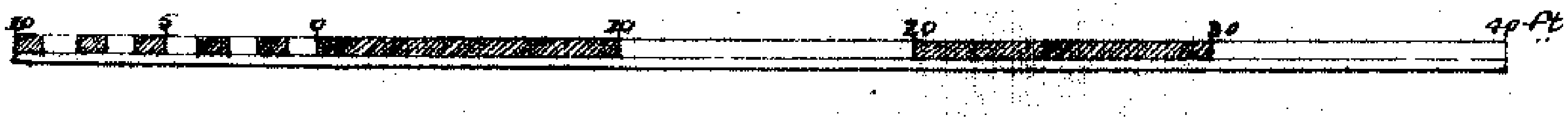


Half Elevation. *Half Section.*

Ground Plan



Scale of 10 feet to an Inch.



C

REFERENCES.

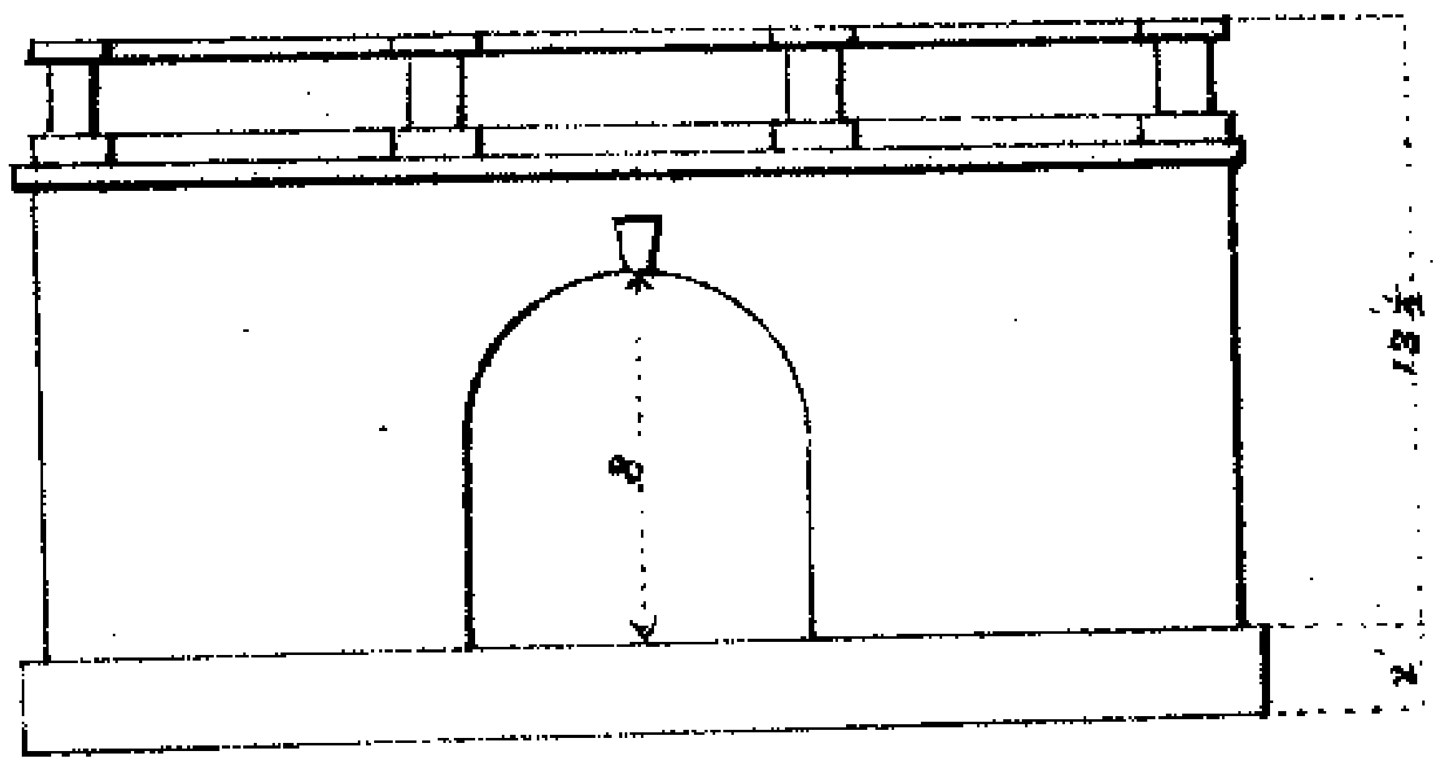
a a a a . . . . Abutments

b b b . . . . . . Aprons

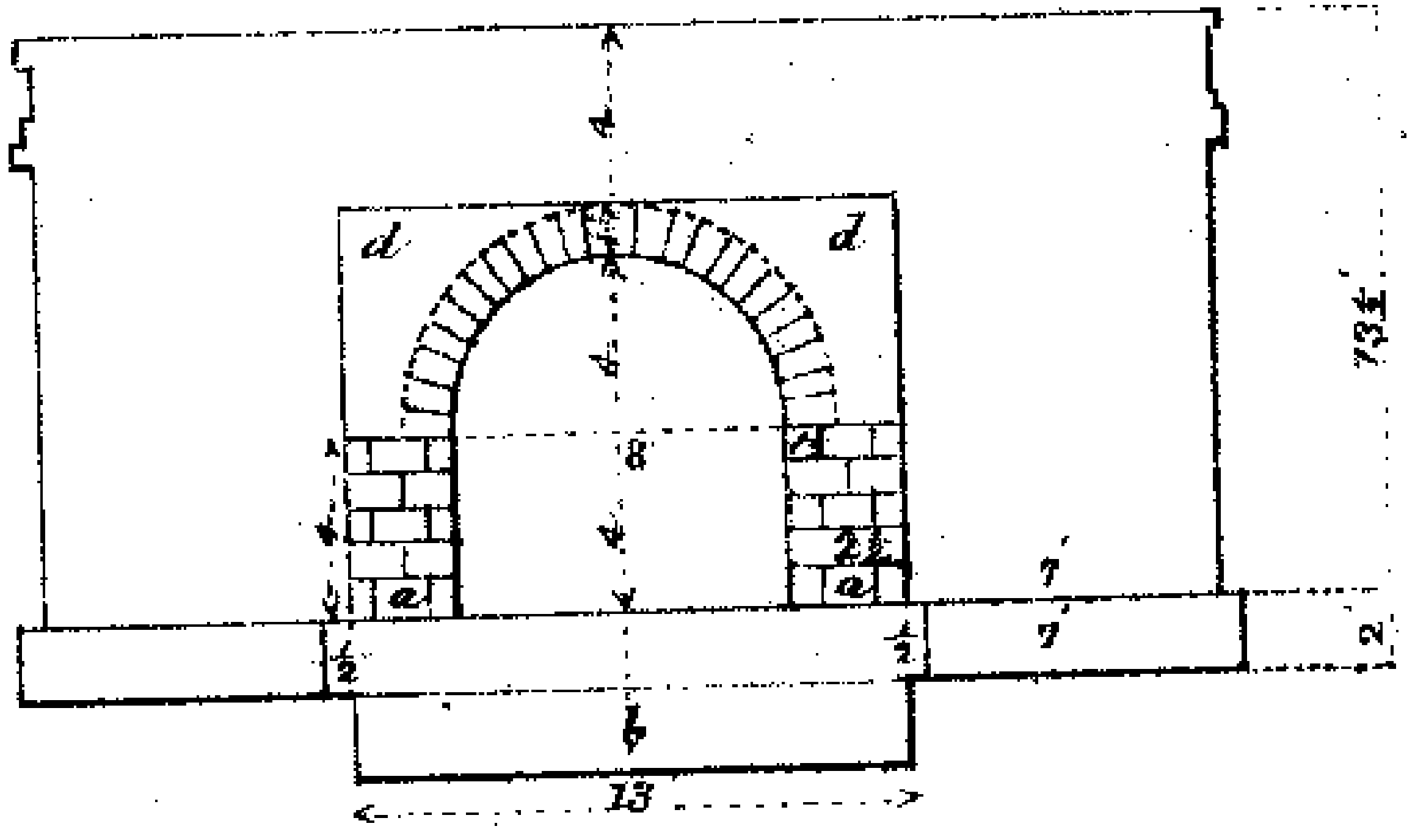
c c c . . . . Wing Walls

N. B. Spandrells are thin longitudinal Walls built from the top of the Abutments to the height or summit of the Arch: the hollows being filled in with small Vaults of masonry, or covered with slabs of stones to make the passage over the arch level vide d d.

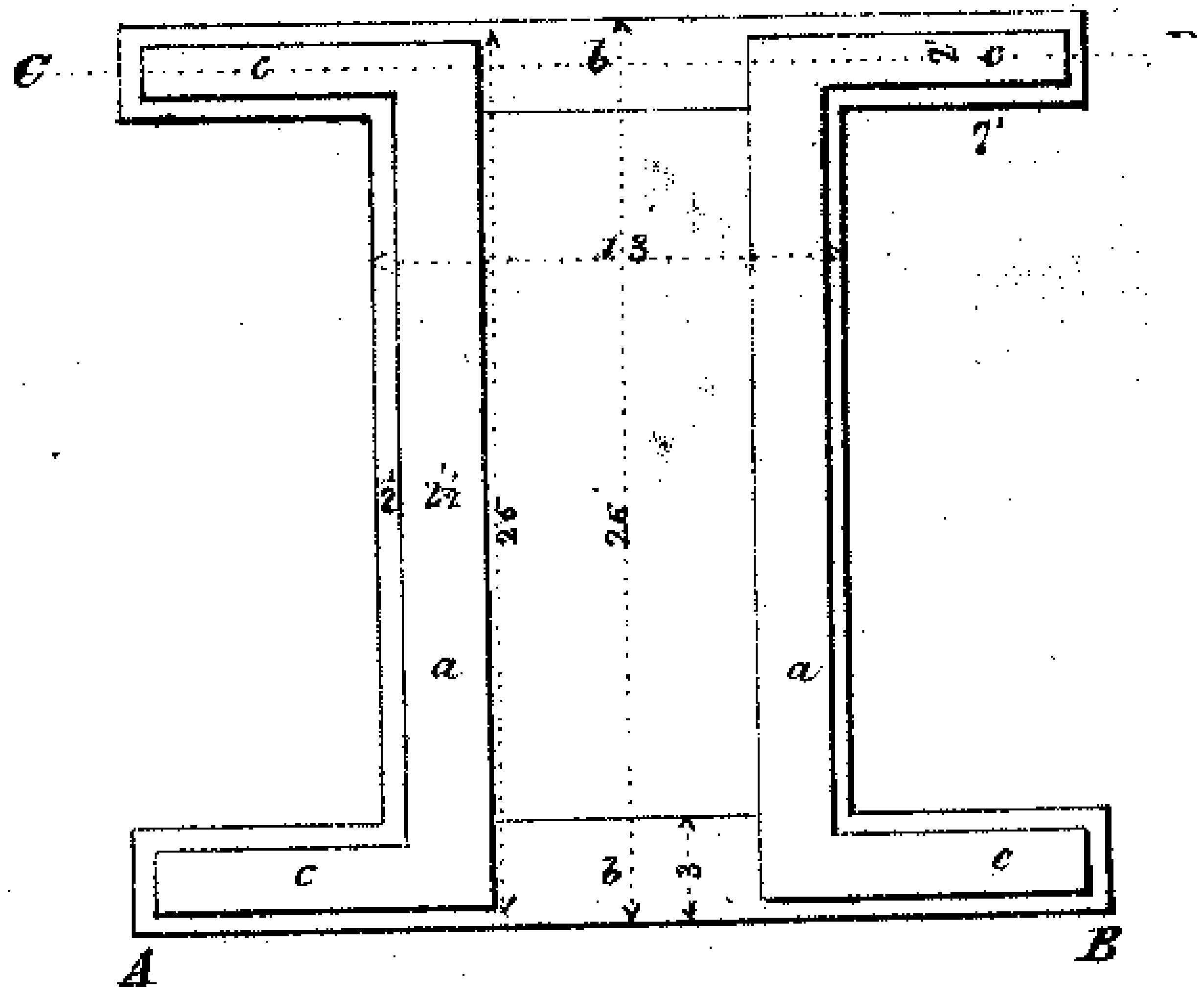
Elevation at A B.



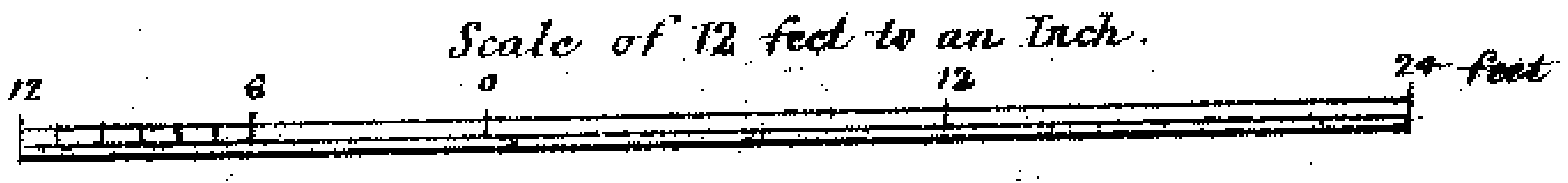
Section thro' C D.



Ground Plan of a Drain Bridge.



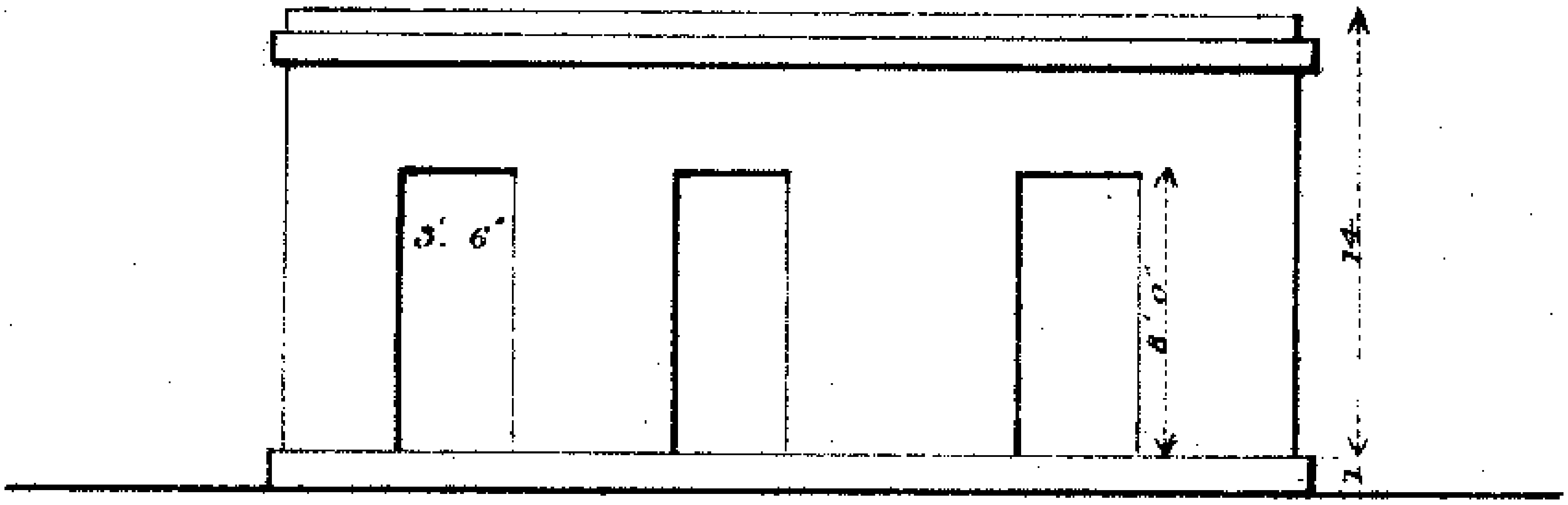
Scale of 12 feet to an Inch.



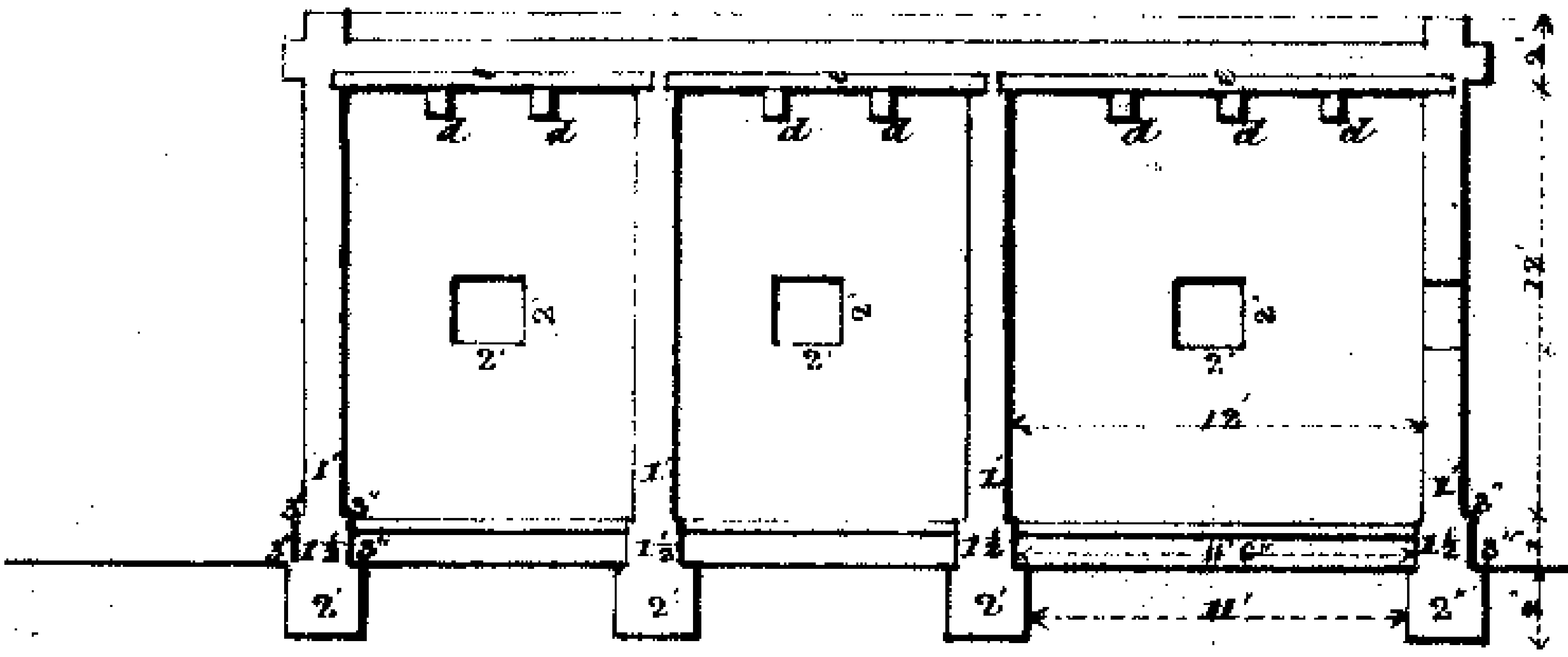
T. BLACK, LITHR: & ENGR: 4 WATERLOO ST CALCUTTA.

(D)

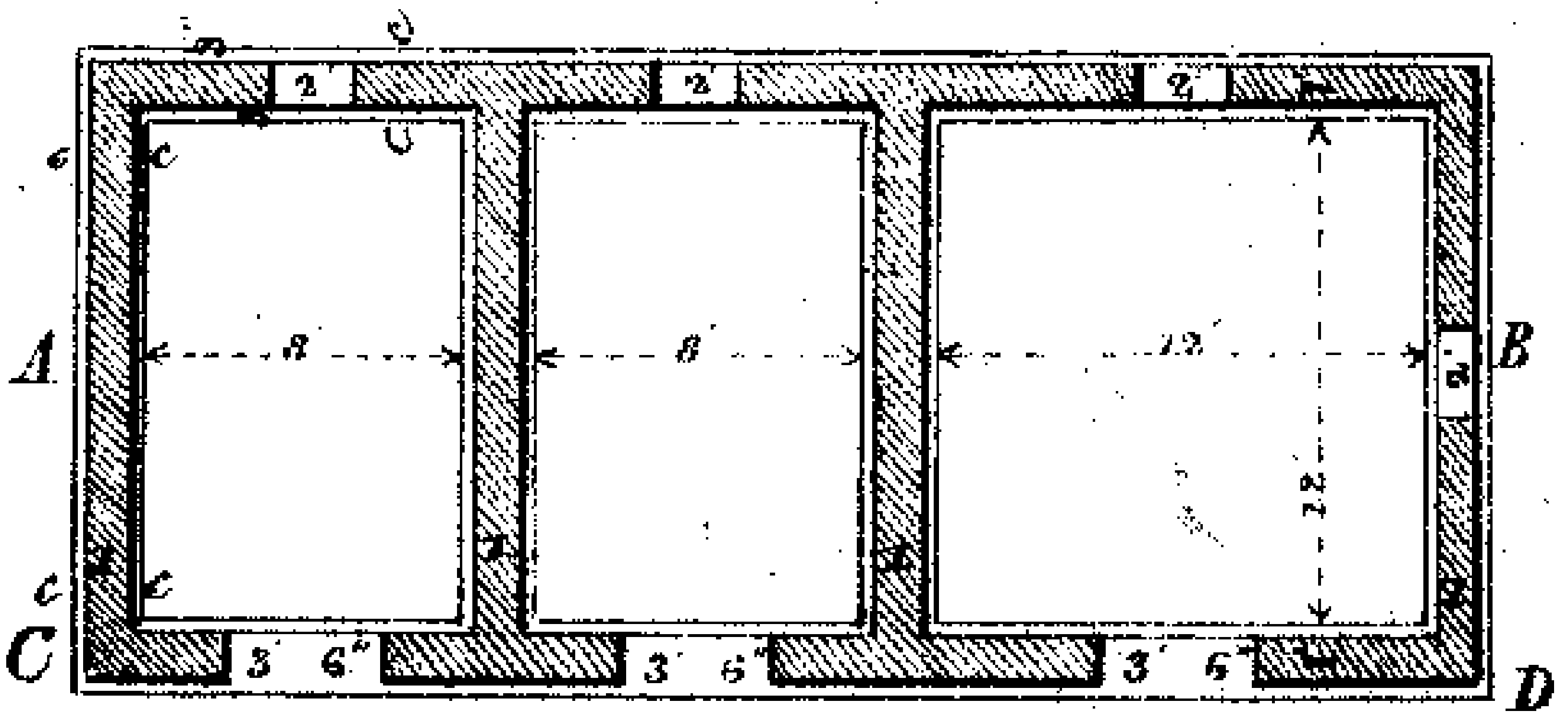
Front View of the Building
or
Elevation at C.D.

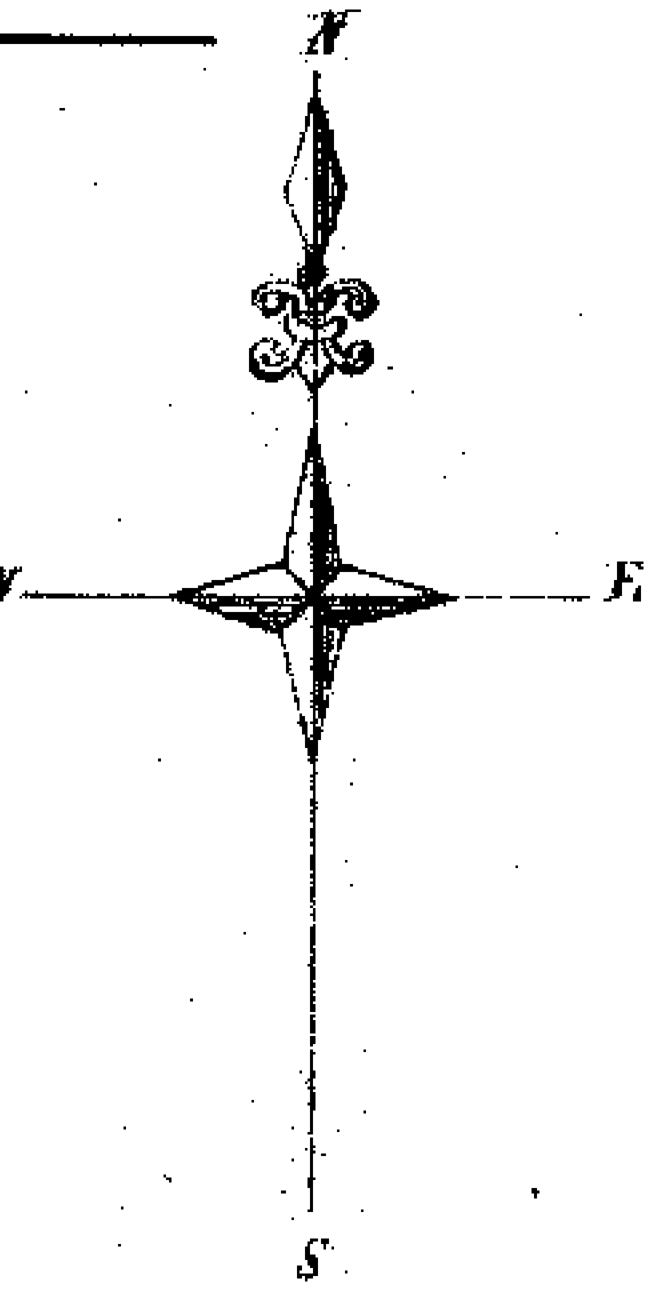


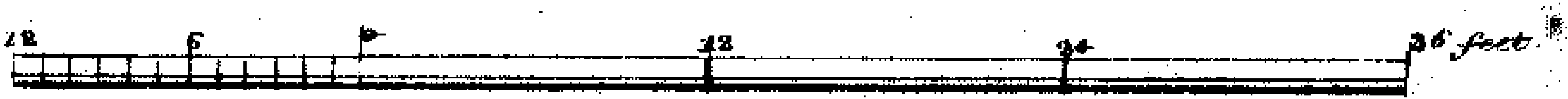
Section thro' A.B.



Ground Plan.







Scale 12 feet to an Inch.